



DEVELOPMENT OF LIMBS

- At the end of 4th week, limb buds appear as outpocketing from the ventrolateral body wall.
- Each limb consists of:
 - 1-mesodermal core derived from somatic layer of lateral plate mesoderm that will form the bones and connective tissues of the limb and some migrating myotomes that will form the muscles.
 - 2- ectodermal covering that will form the skin.

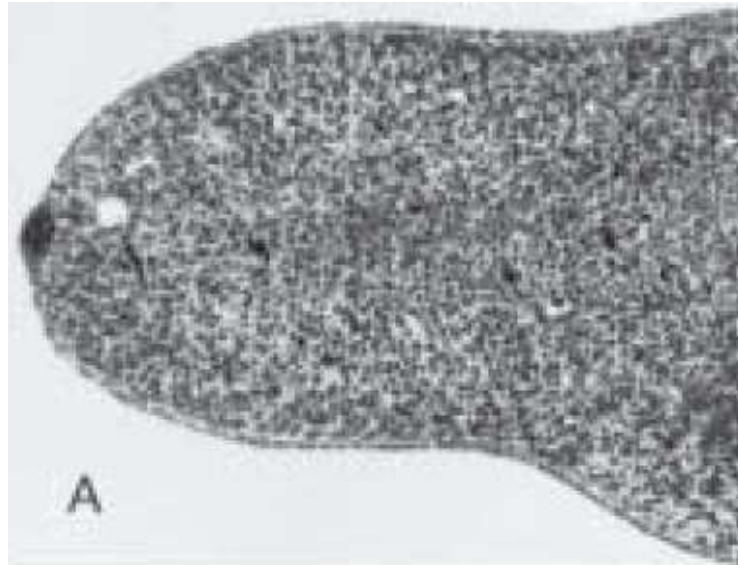
5 weeks



VISIT...

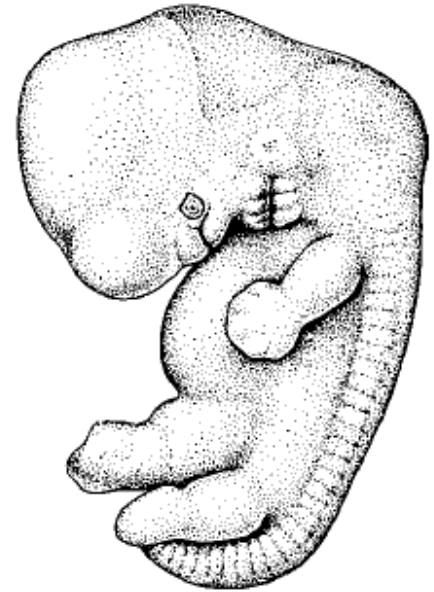
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- Ectoderm at the distal border of the limb thickens to form **apical ectodermal ridge(AER)** which has inductive influence on adjacent mesenchyme (progress zone).

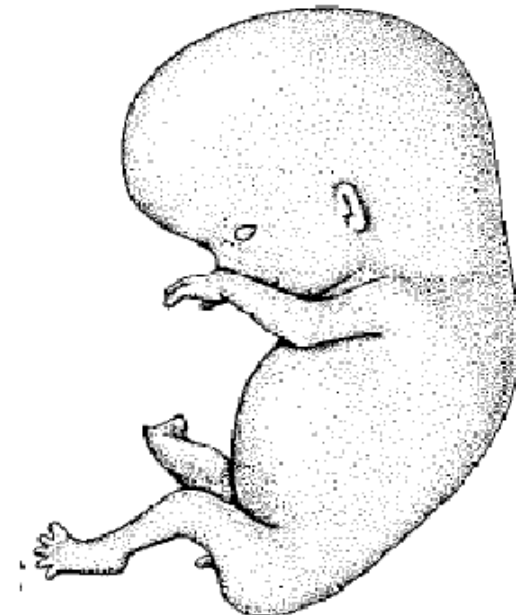


- In 6 week- old embryos, the terminal portion of the limb buds flattened to form the hand- and footplates and is separated from the proximal segment by a circular constriction.
- Later, a second constriction divides the proximal portion into 2 segments.

6 weeks



8 weeks



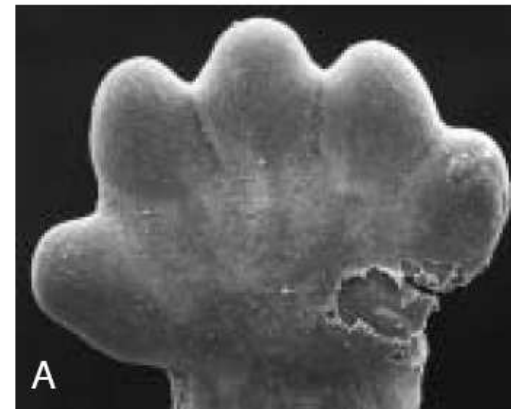
-Fingers and toes are formed when cell death in the AER separates this ridge into 5 parts.

- Then mesodermal condensations in the hand and foot will form digital rays.

-Development of the upper and lower limbs are similar except:

1- morphogenesis of the lower limb is 1 to 2 days later.

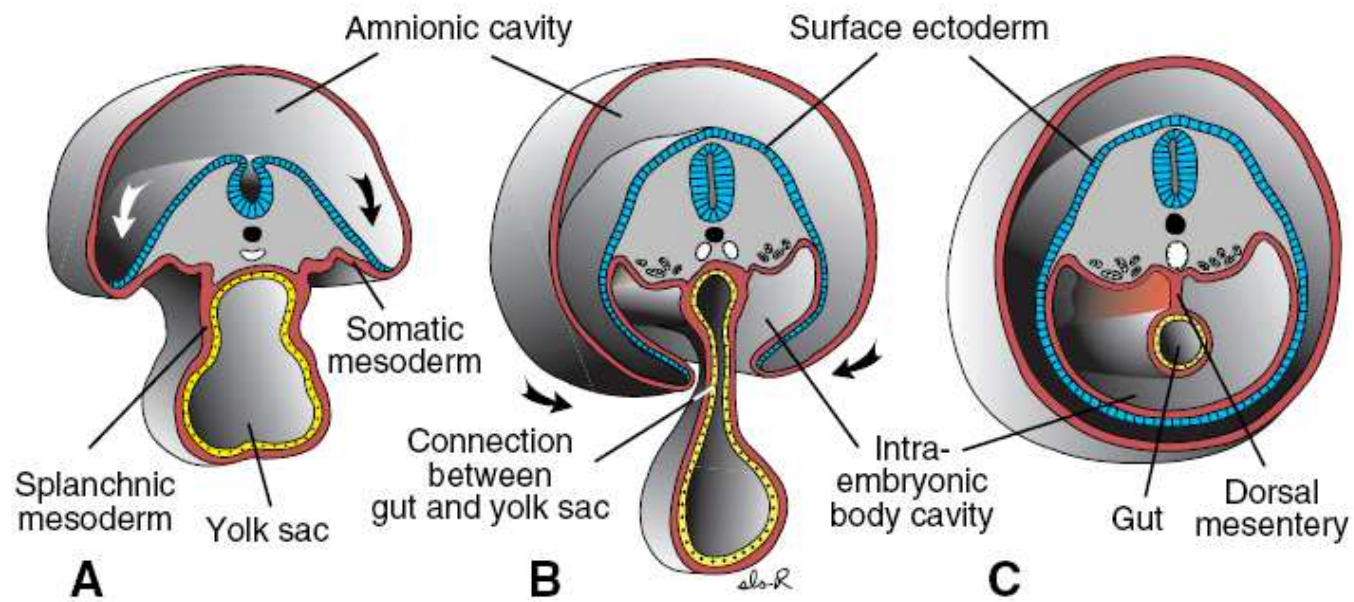
2- During the 7th week the upper limb rotates 90 degree laterally whereas the lower limb rotates medially.

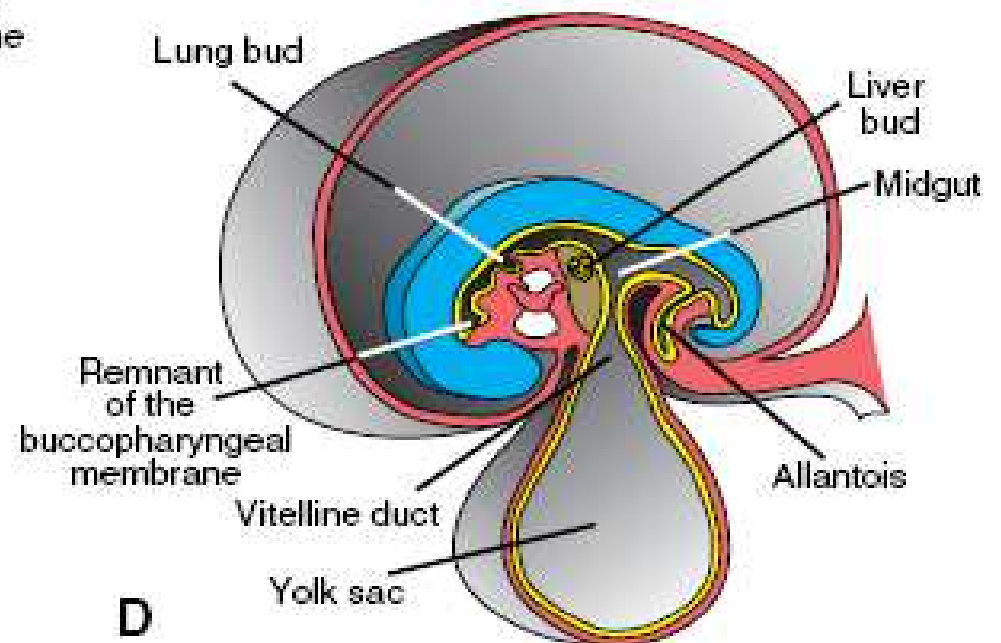
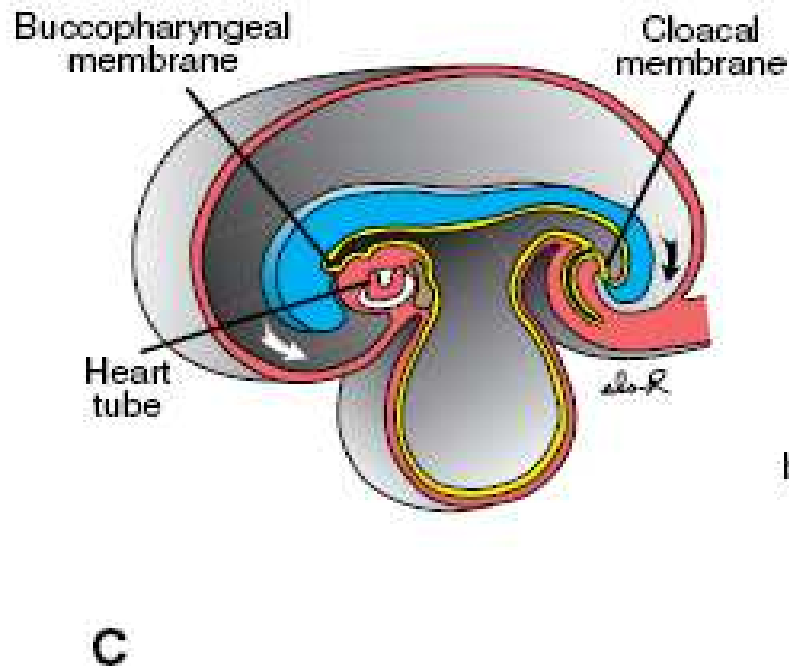
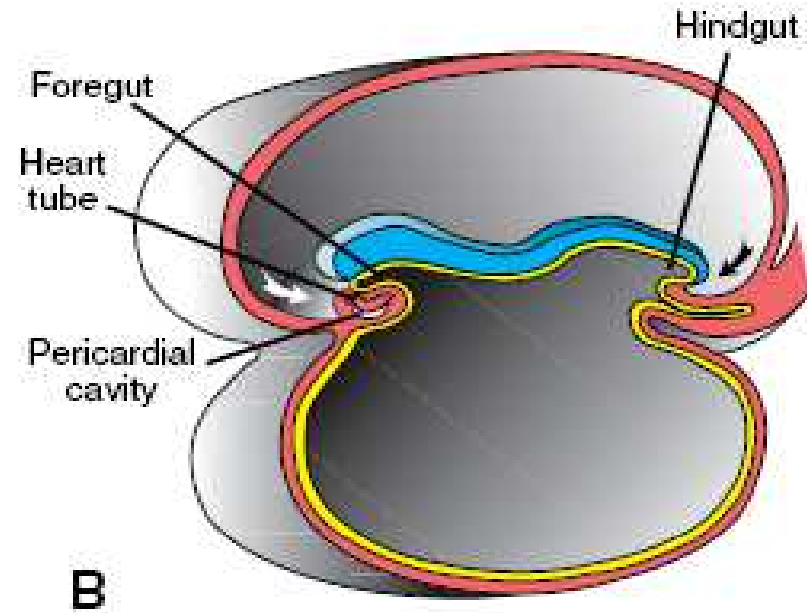
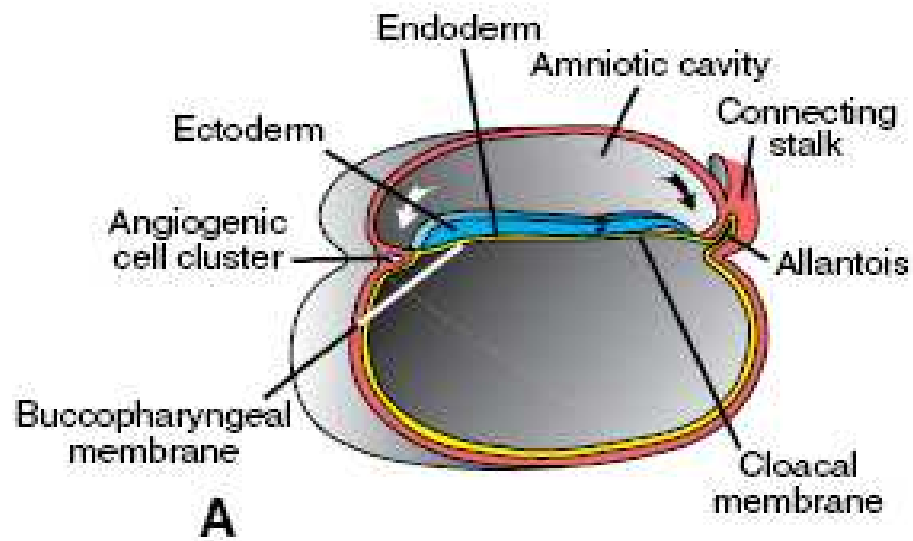


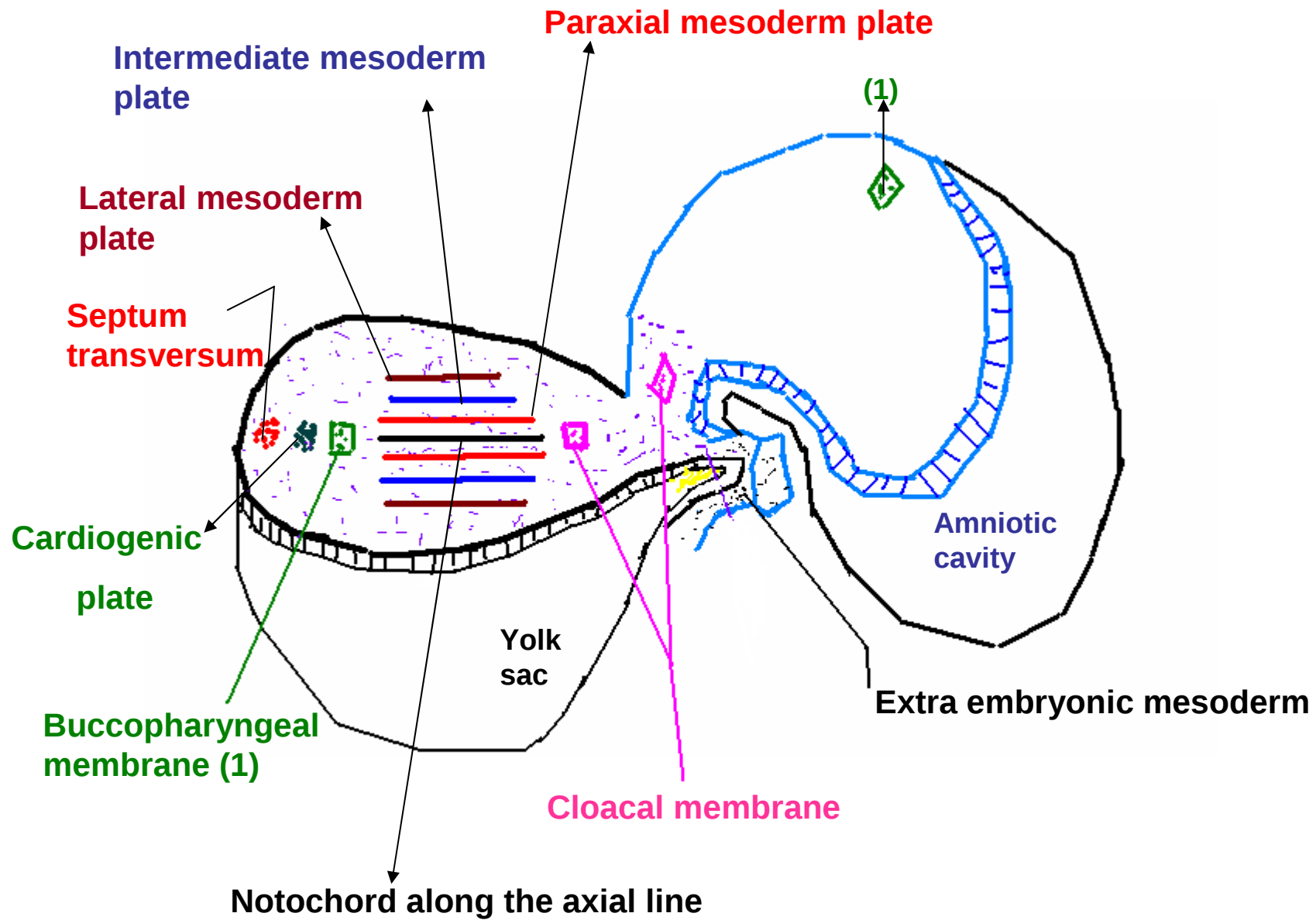
Limb Defects:

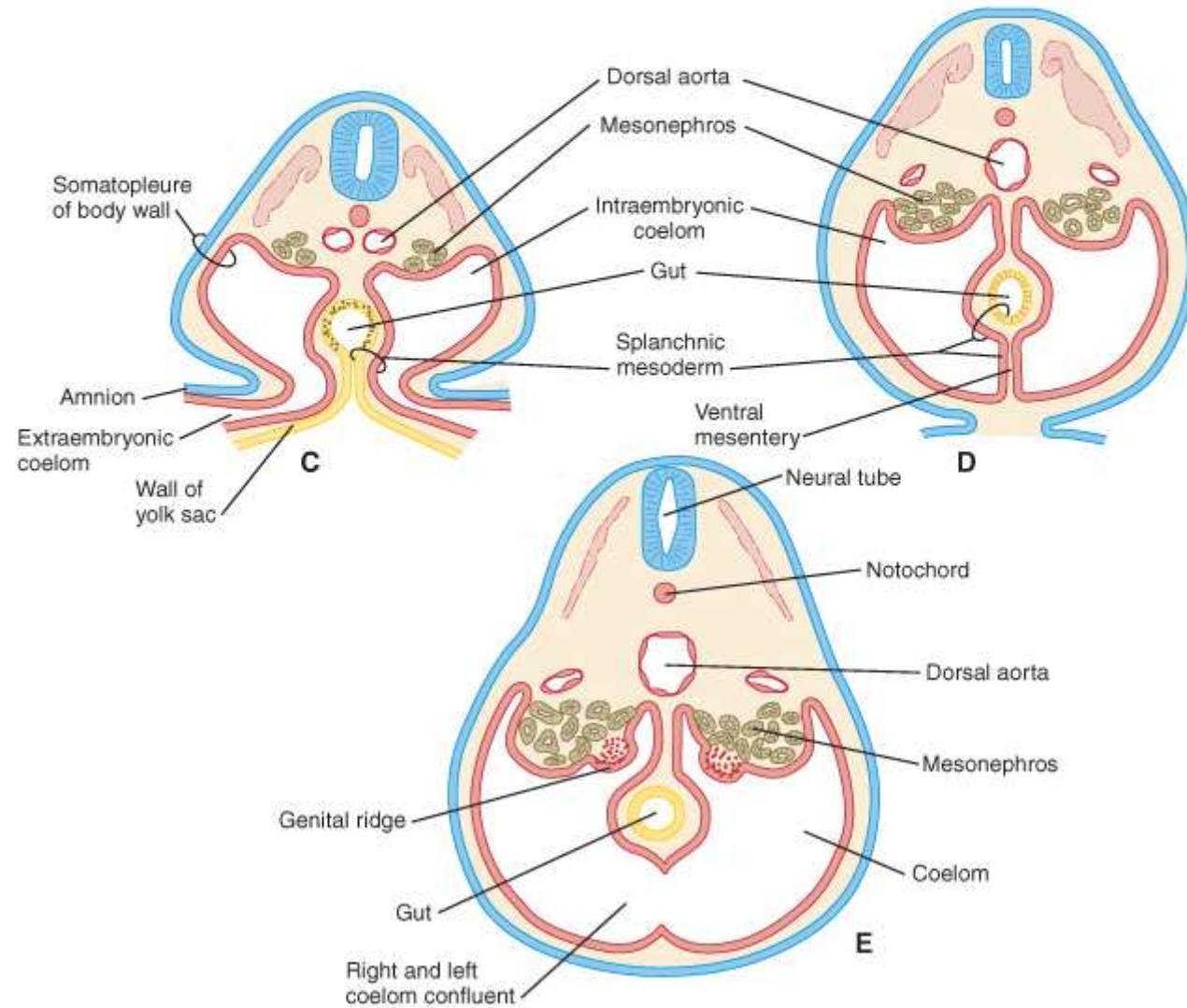
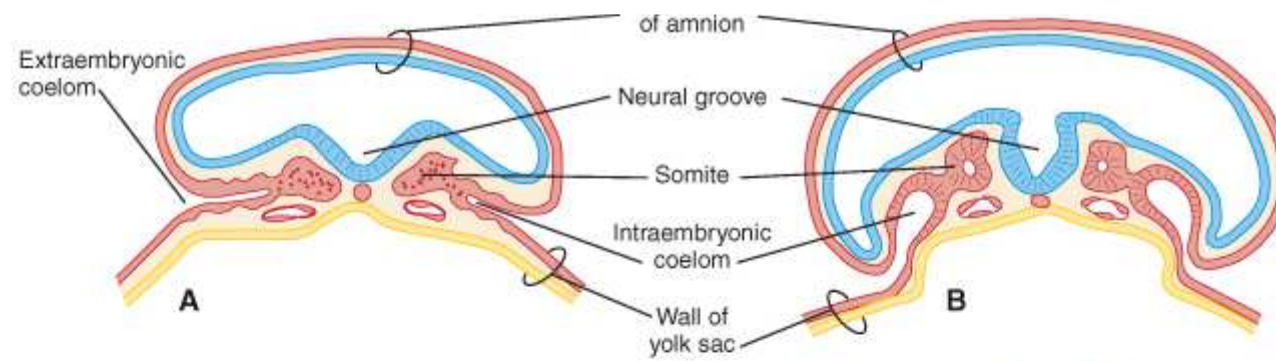
- 1- Partial absence of 1 or more of the extremities (**meromelia**).
- 2- Complete absence(**amelia**).
- 3- Abnormal short segments of the extremities(**micromelia**).
- 4- Short digits (**brachydactyly**).
- 5- 2 or more fingers or toes fused (**syndactyly**).
- 6- **Club foot**:the feet are plantar flexed and inverted.
- 7- **Polydactyly**: extra fingers or toes.
- 8- **Ectrodactyly**: absence of a digit.
- 9- **Cleft hand or foot (lobster claw deformity)**:abnormal cleft between 2nd and 4th metacarpal bones

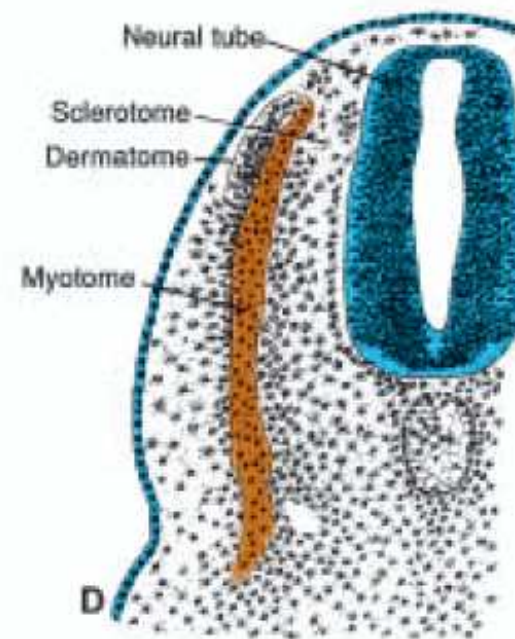
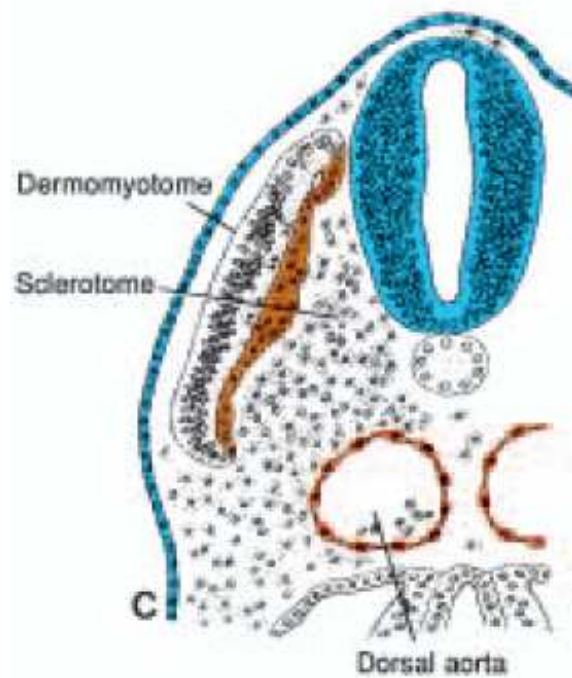
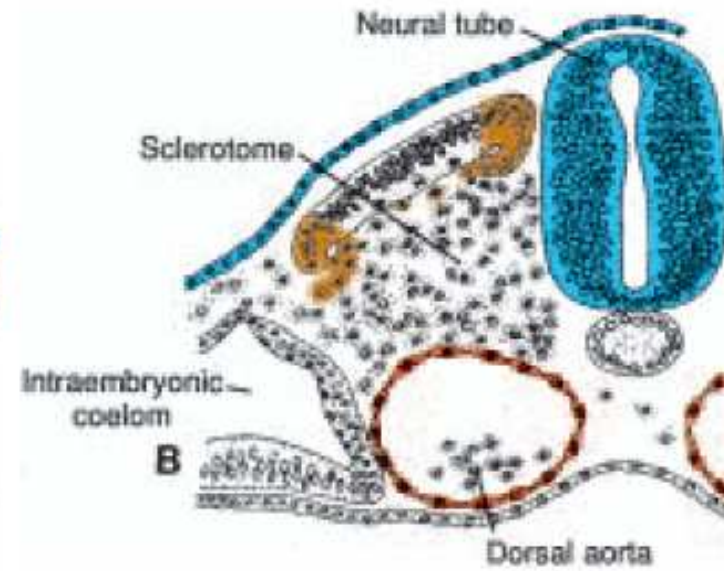
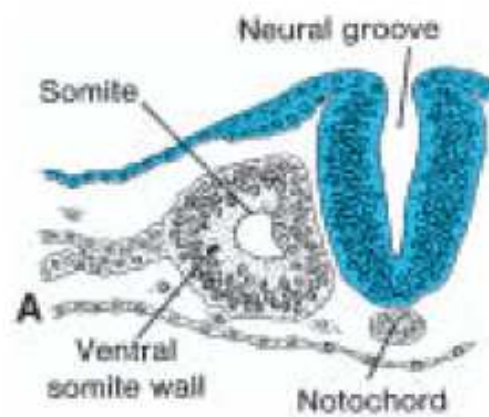






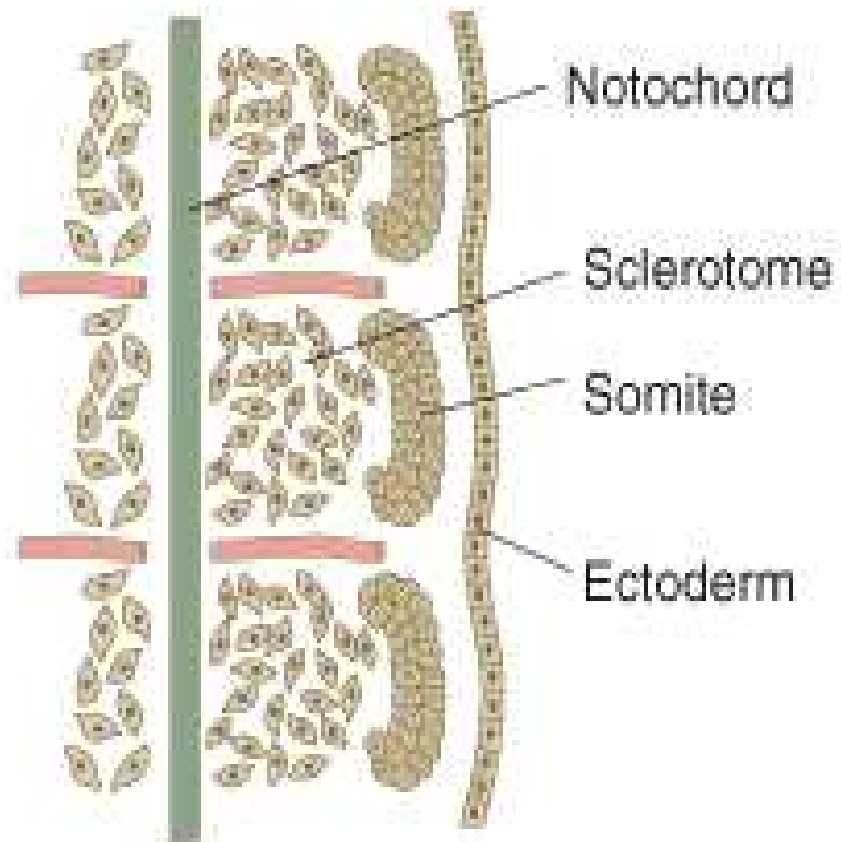




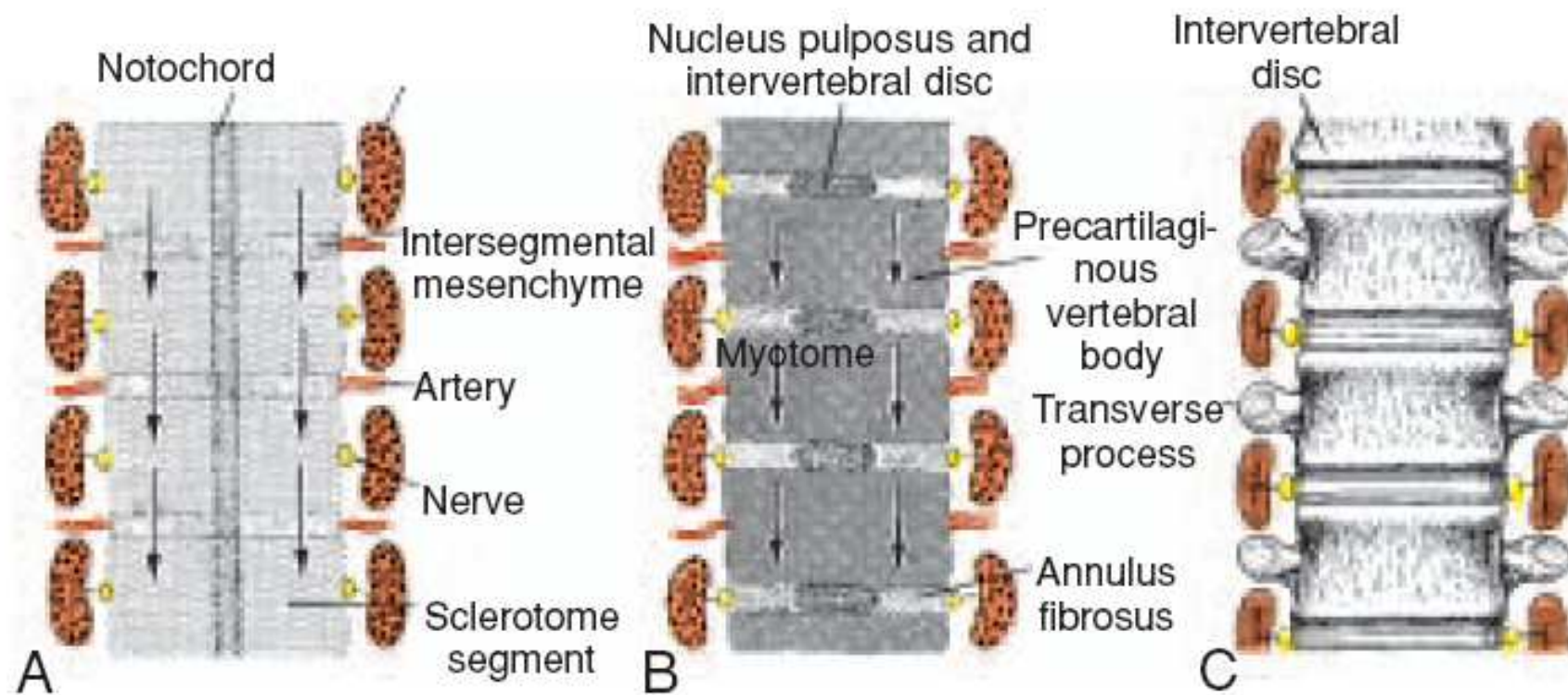


DEVELOPMENT OF VERTEBRAL COLUMN

- During the fourth week of development, cells of the sclerotomes shift their position to surround both the spinal cord and the notochord.
- The caudal portion of each sclerotome segment proliferates extensively and condenses .This proliferation is so extensive that it binds the caudal half of one sclerotome to the cephalic half of the subjacent sclerotome.



Sclerotome forms the axial skeleton

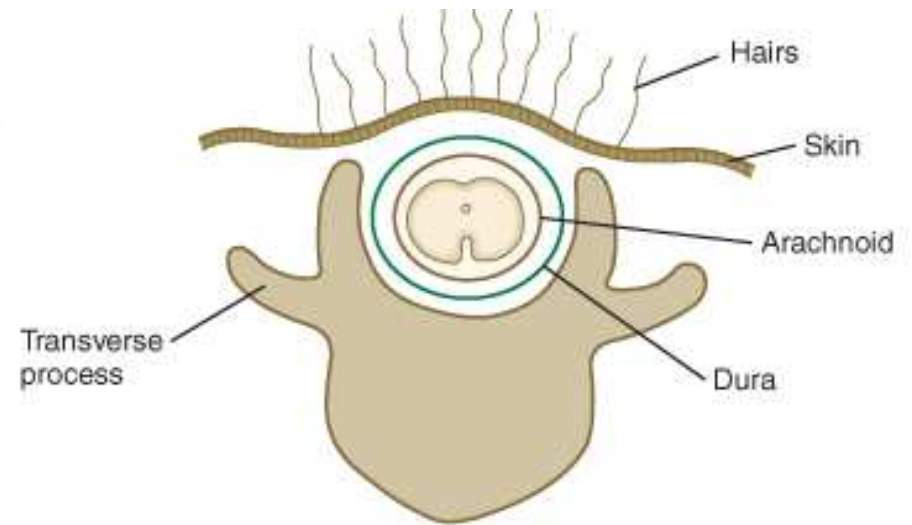
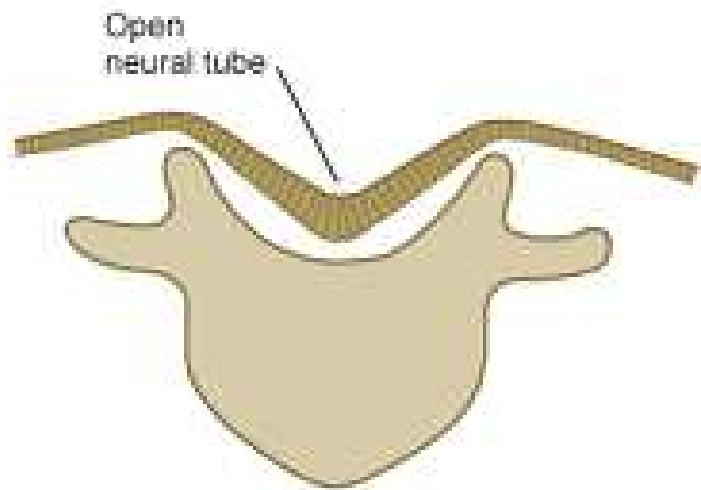


- Mesenchymal cells between cephalic and caudal parts of the original sclerotome segment do not proliferate but fill the space between two vertebral bodies so they contribute to formation of the intervertebral disc.

- the notochord regresses entirely in the region of the vertebral bodies but it persists and enlarges in the region of the intervertebral disc to form the nucleus pulposus, which is later surrounded by circular fibers of the annulus fibrosus. These two structures form the intervertebral disc.

VERTEBRAL DEFECTS:

- 1- Spina bifida occulta:** due to failure of fusion of vertebral arches leaving the spinal cord intact ,so the defect is covered by skin and no neurological deficits occur.
- 2- Spina bifida cystica:** the neural tube fails to close,vertebral arches fail to fuse and neural tissue is exposed.
- 3- Scoliosis:** lateral curving of the spine.



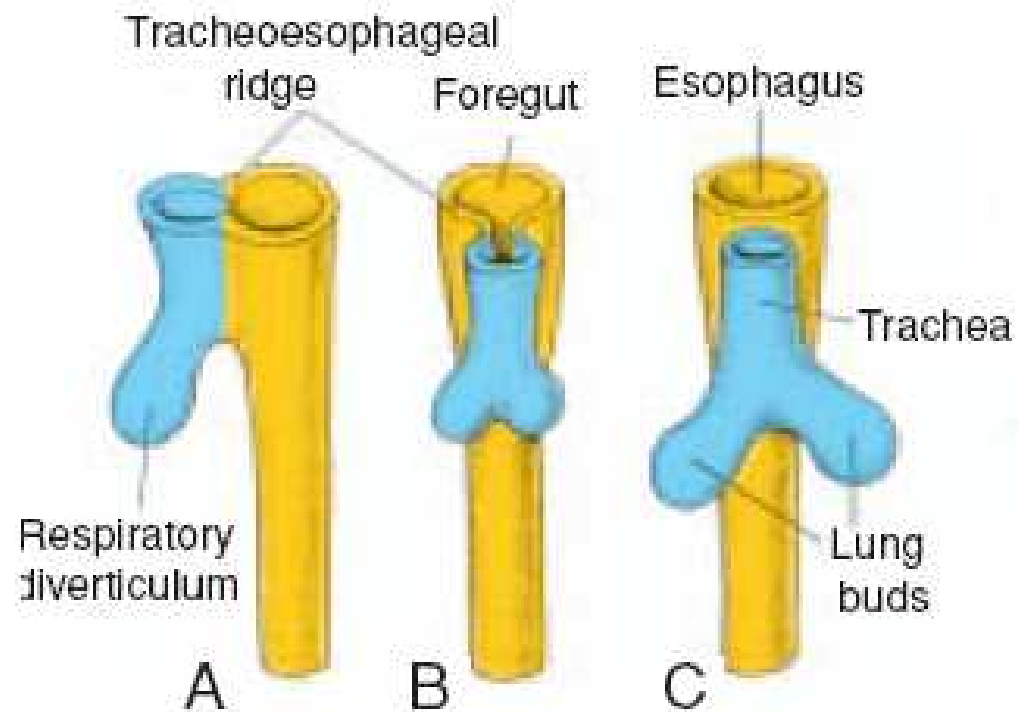
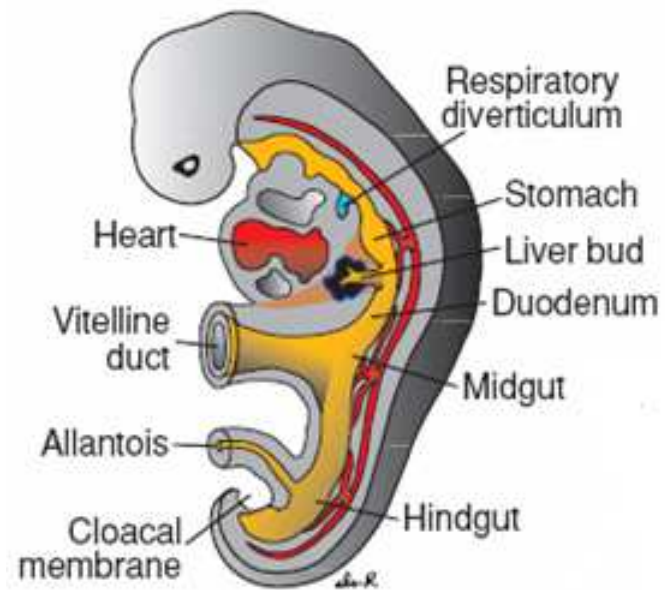
RESPIRATORY SYSTEM

- It begins to develop at the age of 4 weeks.
- It arises as an outgrowth from the ventral wall of the foregut called **respiratory diverticulum or lung bud**.
- As the diverticulum expands caudally , 2 longitudinal ridges (tracheoesophageal ridges) separate it from the foregut.
- Then these ridges fuse to form tracheoesophageal septum.

so the foregut is now divided into 2parts:

- 1- dorsal part (the oesophagus).
- 2- ventral part (the laryngeotracheal tube).

N.B. The respiratory system maintains its communication with the pharynx through the laryngeal inlet.



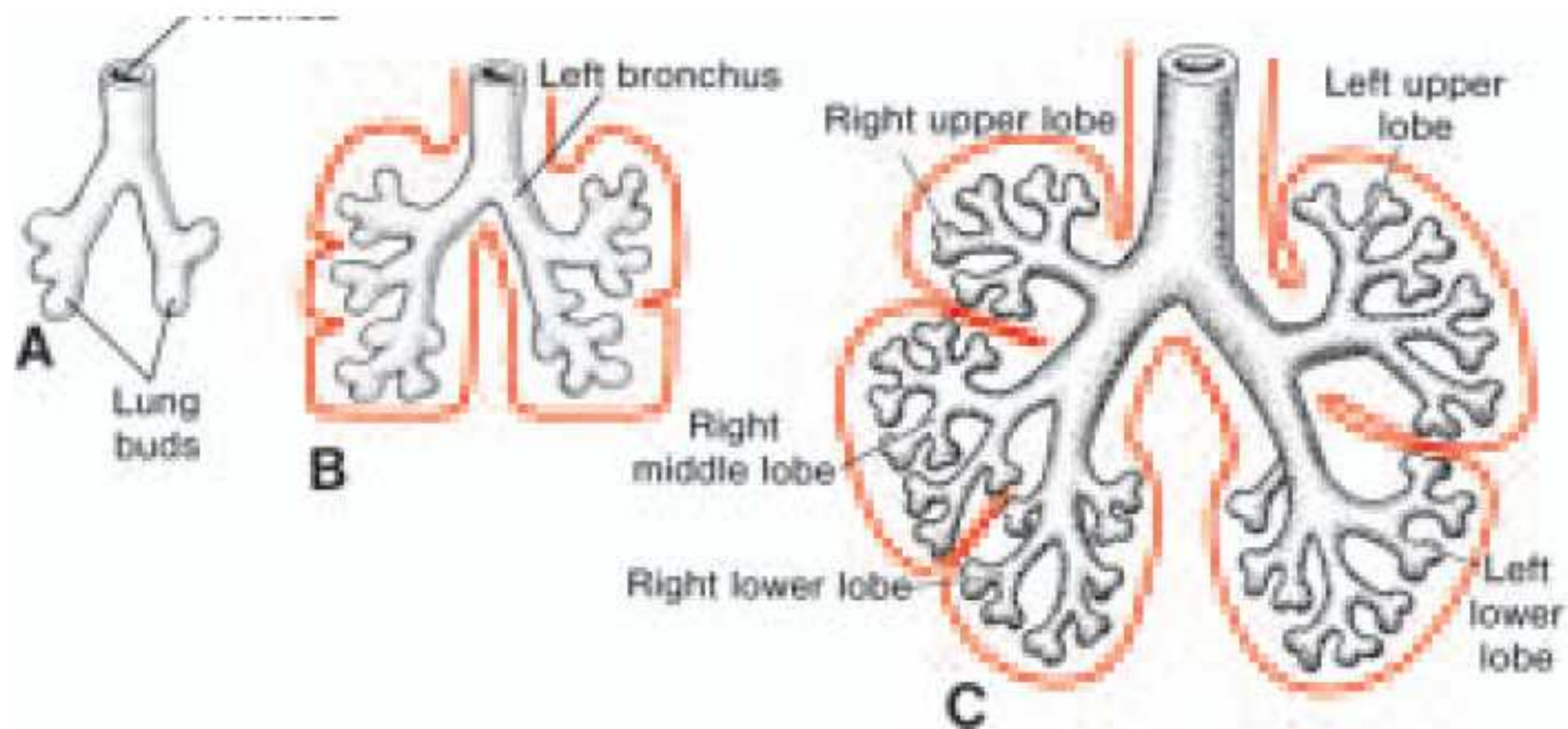
- The upper end of the laryngeotracheal tube forms the larynx, while its lower end forms the lung buds.
- The lung bud develops into 2 main bronchi.

The right forms 3 secondary bronchi and 3 lobes.

The left forms 2 secondary bronchi and 2 lobes.

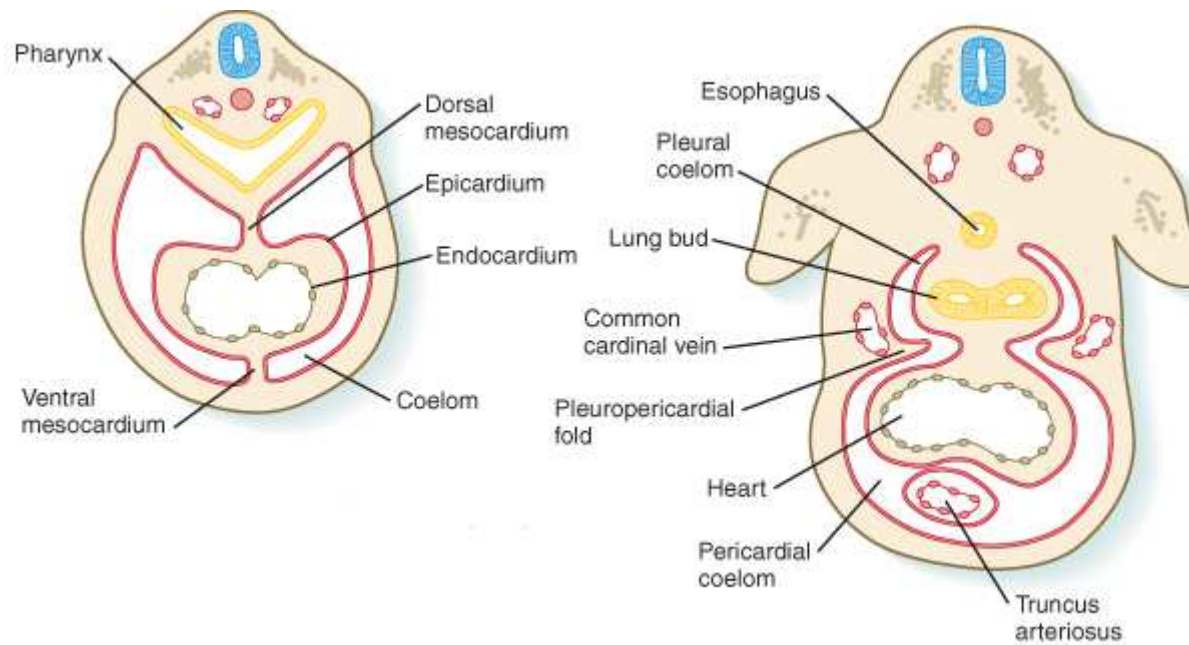
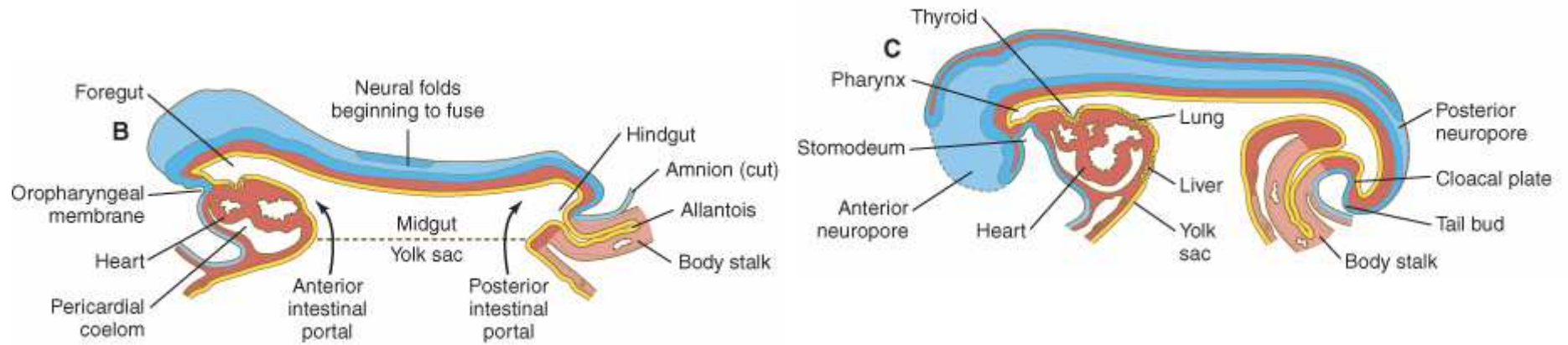
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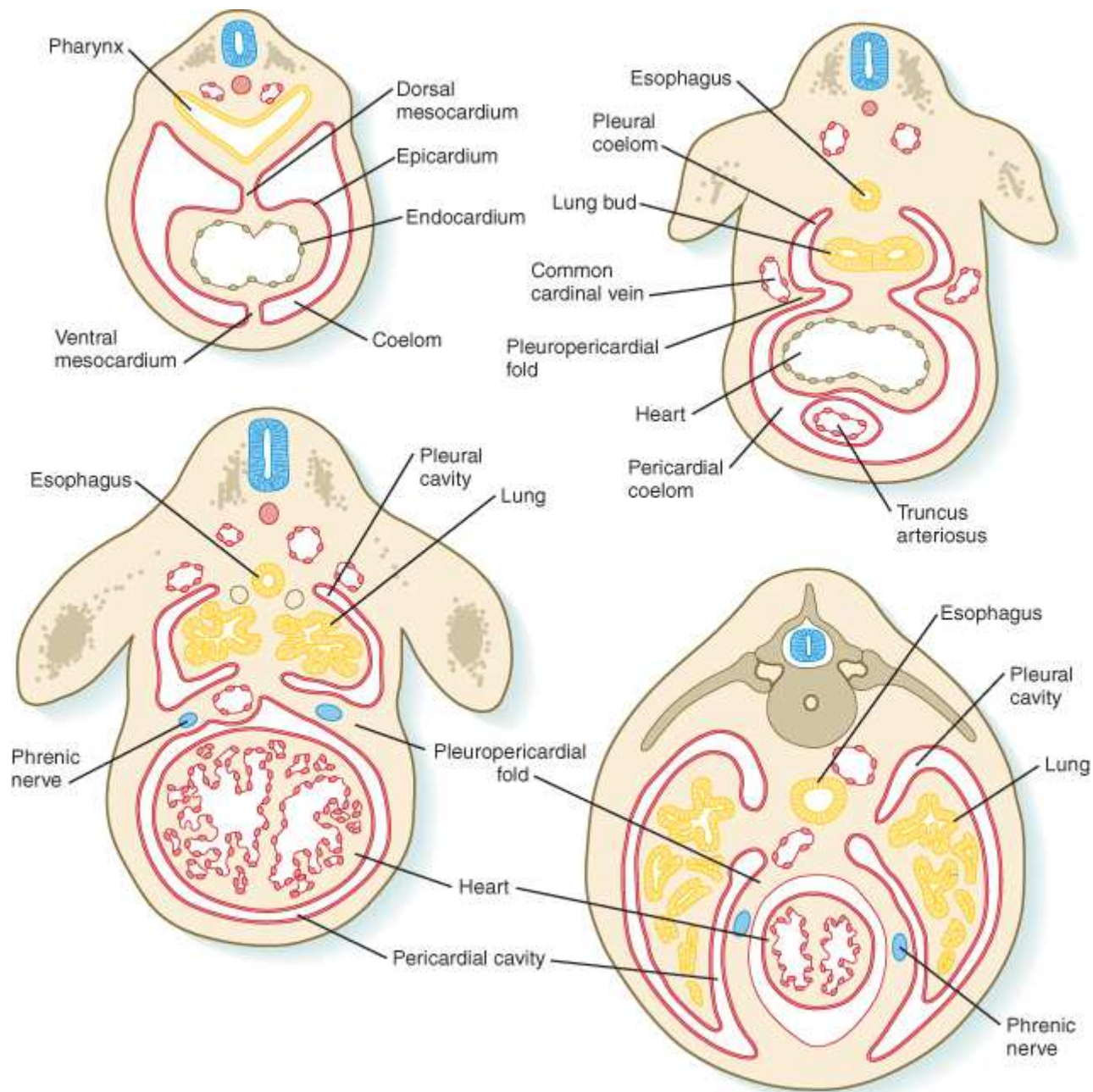
- The epithelium of the larynx, trachea , bronchi and alveoli arises from the endoderm of gut tube.
- The cartilage, muscles, blood vessels and connective tissue arise from splanchnic mesoderm that surrounds the gut.

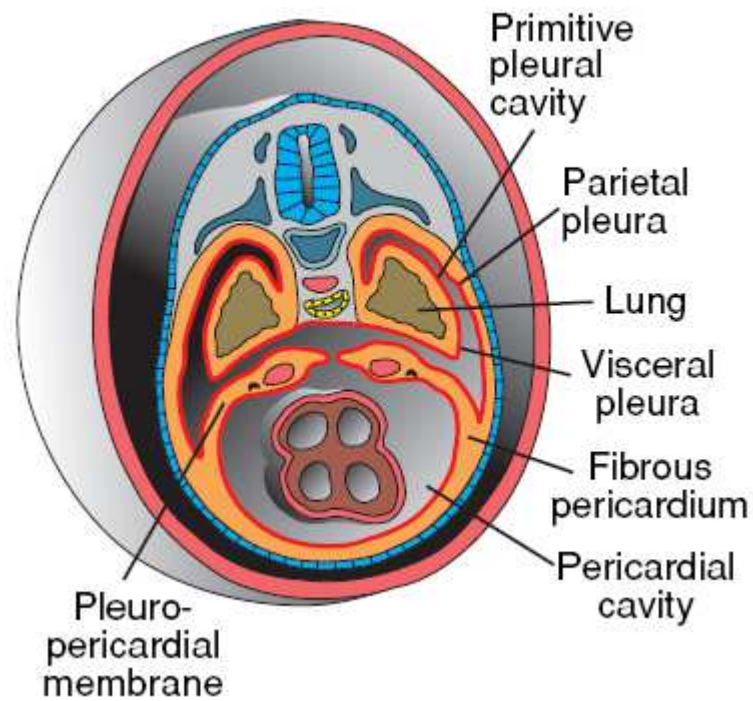
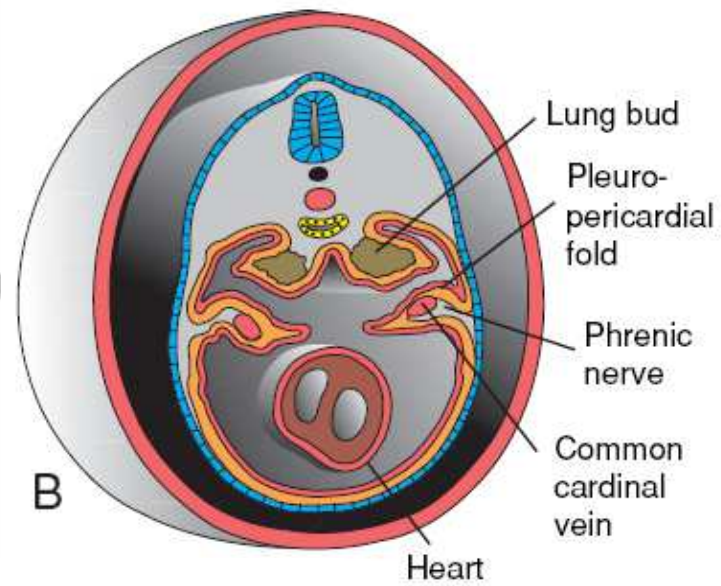
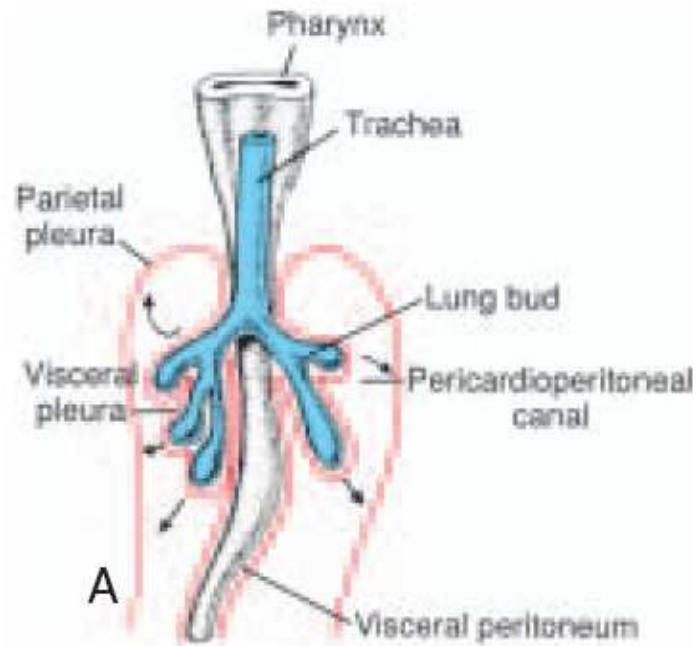


Invasion of the pleura:

- **Each lung grows laterally around the foregut and invaginates part of the intraembryonic coelom (the pericardio-peritoneal canal) which gives the pleural sac.**
- **The visceral pleura is derived from splanchnic mesoderm (supplied by autonomic nerves) whereas the parietal pleura is derived from somatic mesoderm (supplied by somatic nerves).**







Maturation of the lung:

The lung passes through 4 stages during development which are:

1- Pseudoglandular stage(5-16 weeks):formed of bronchi and terminal bronchioles only.

2- Canalicular stage(16-26 weeks):respiratory bronchioles and alveolar ducts developed with vascularisation of the lung.

3- Terminal sac stage(26 weeks- birth): primitive alveoli are formed lined with cells which produce **surfactant (a phospholipid which lowers the surface tension of the alveoli helping their expansion after birth) which increases during the last 2 weeks. A foetus born during this period can survive.**

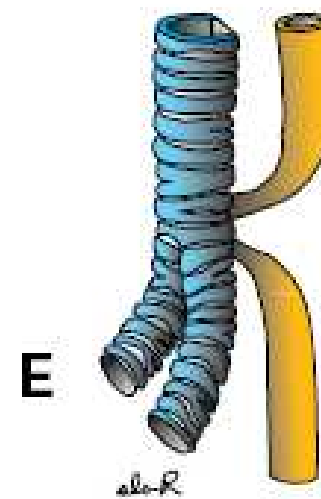
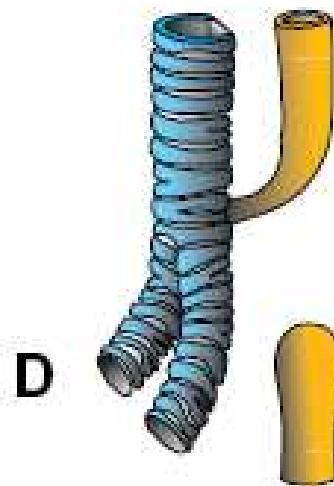
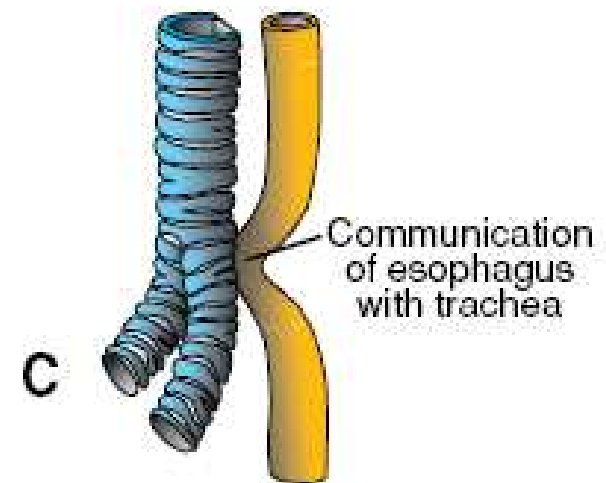
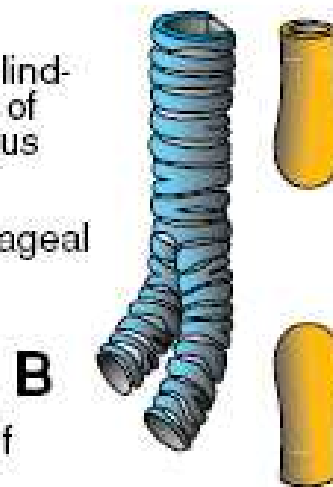
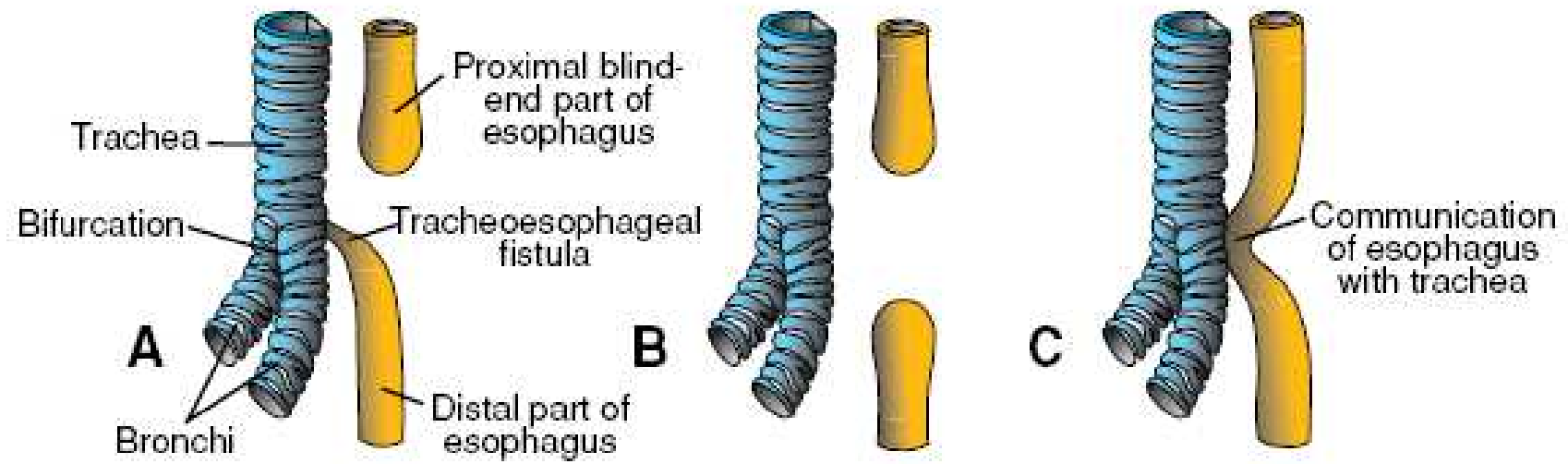
4- Alveolar stage(late prenatal- 10 years postnatal):the number of alveoli increases.Mature alveoli are not present before birth.

Congenital anomalies:

1- Esophageal atresia with or without tracheoesophageal fistula: the fistula results from incomplete fusion of tracheoesophageal folds.

2- Hyaline membrane disease(HMD): due to deficiency of surfactant causing respiratory distress syndrome.

3- Lung anomalies: include agenesis, hypoplasia (small lung), variation in lobes number, accessory lung, ectopic lung lobes(from trachea or esophagus) and congenital lung cyst.

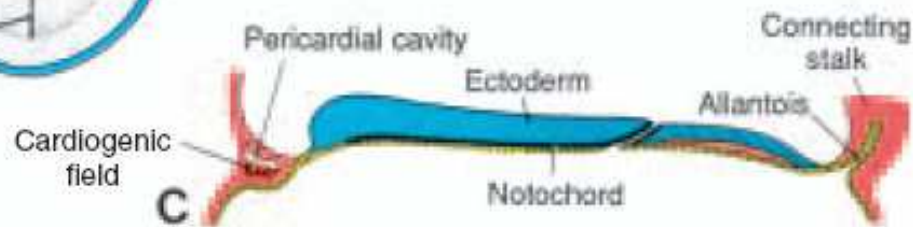
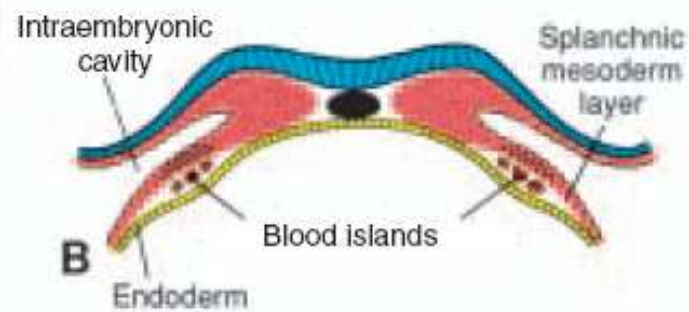
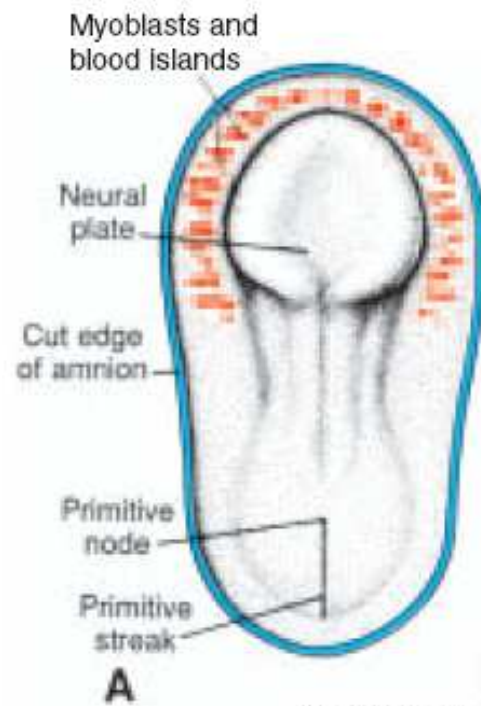
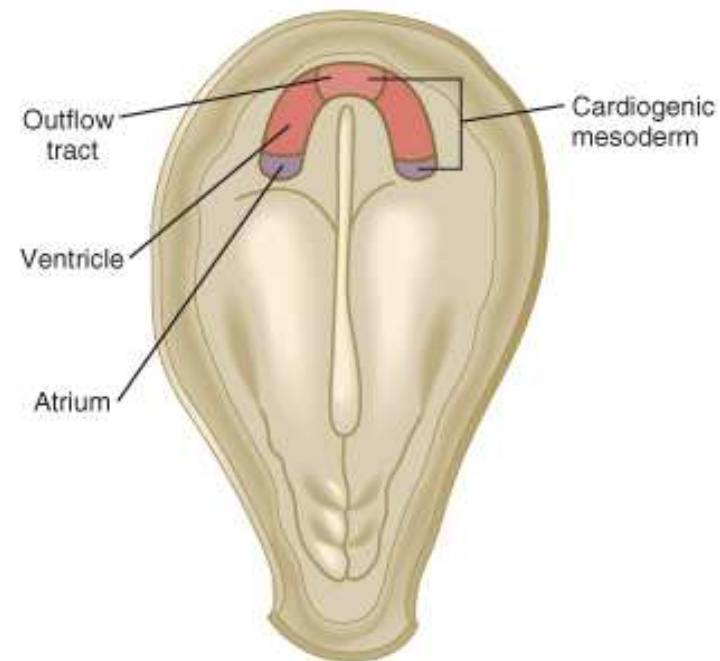


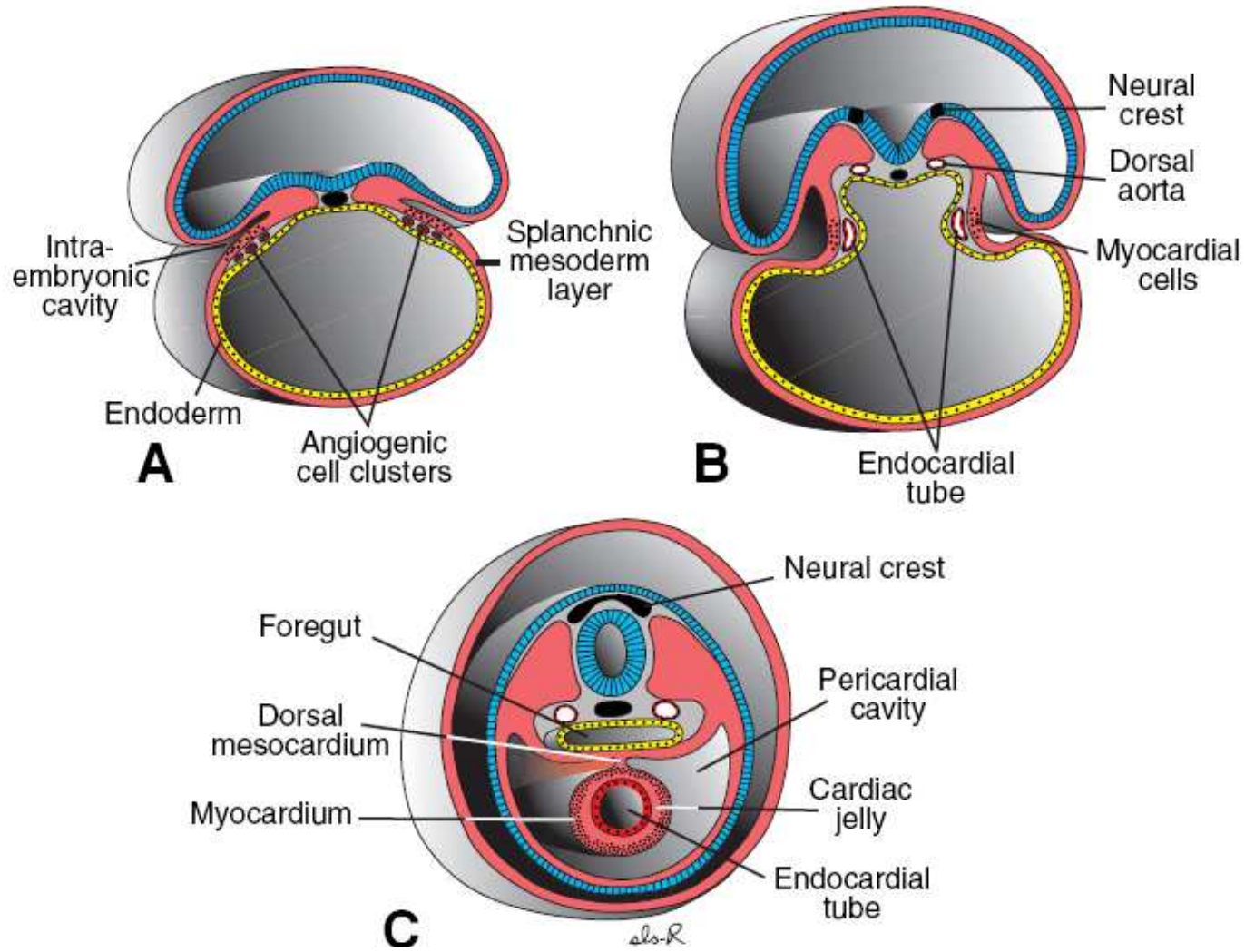
CARDIOVASCULAR SYSTEM

- All the cardiovascular system develops from mesoderm.

Development of the heart:

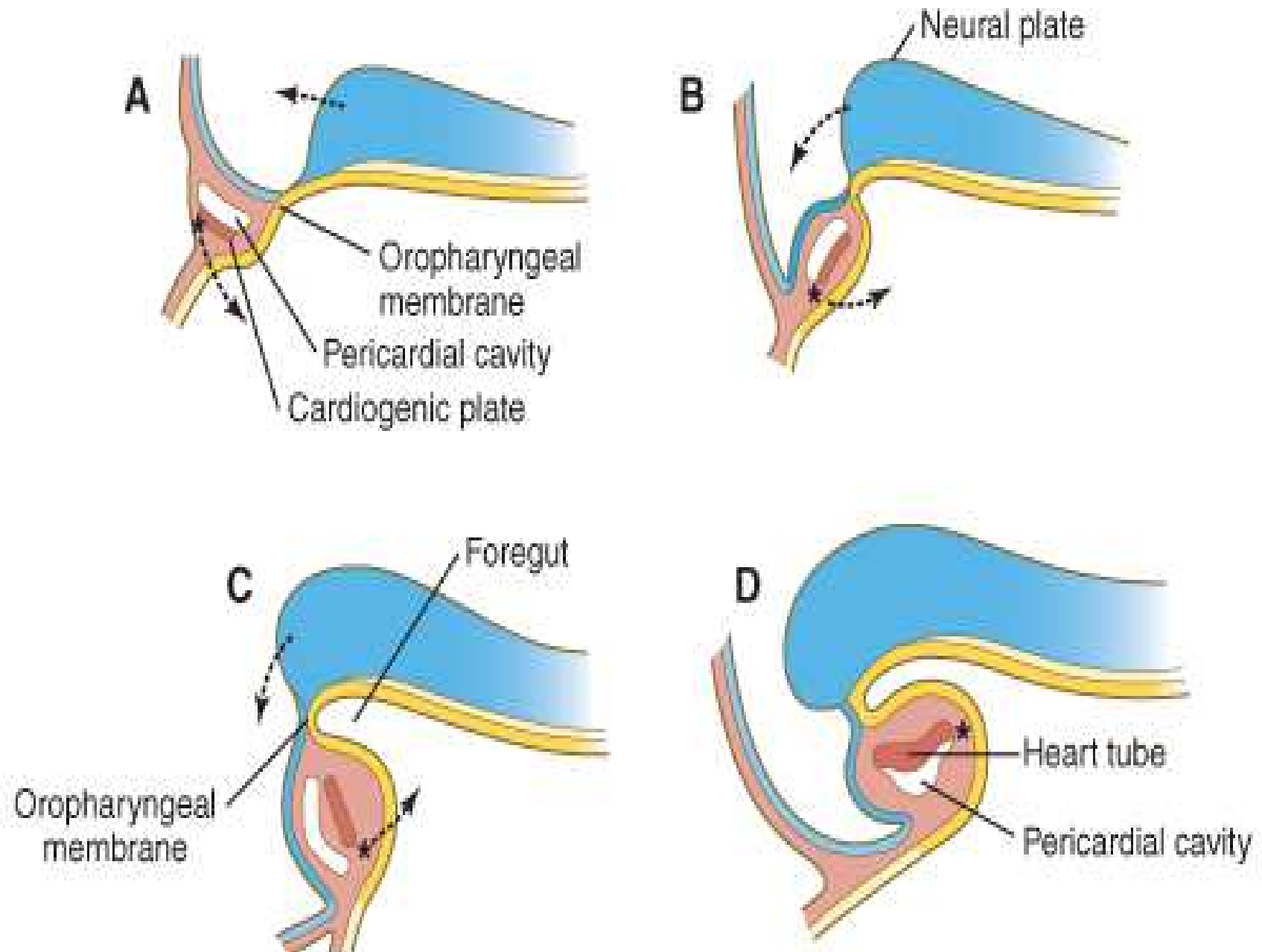
- It develops from the splanchnic mesoderm which lies in front of the buccopharyngeal membrane and ventral to the pericardial sac (**cardiogenic area**).
- The angiogenic cells in this area form 2 endocardial heart tubes.
- Later, the 2 tubes fuse together and form a single tube which will form the endocardium of the heart.
- The splanchnic mesoderm between the pericardial sac and the heart tube form the myoepicardial mantle which will give rise to the myocardium and epicardium.





- As the result of folding of the embryo, the heart tube becomes:

- ventral to the foregut.**
- cranial to the septum transversum.**
- dorsal to the pericardial sac.**



Changes that occur to the heart tube:

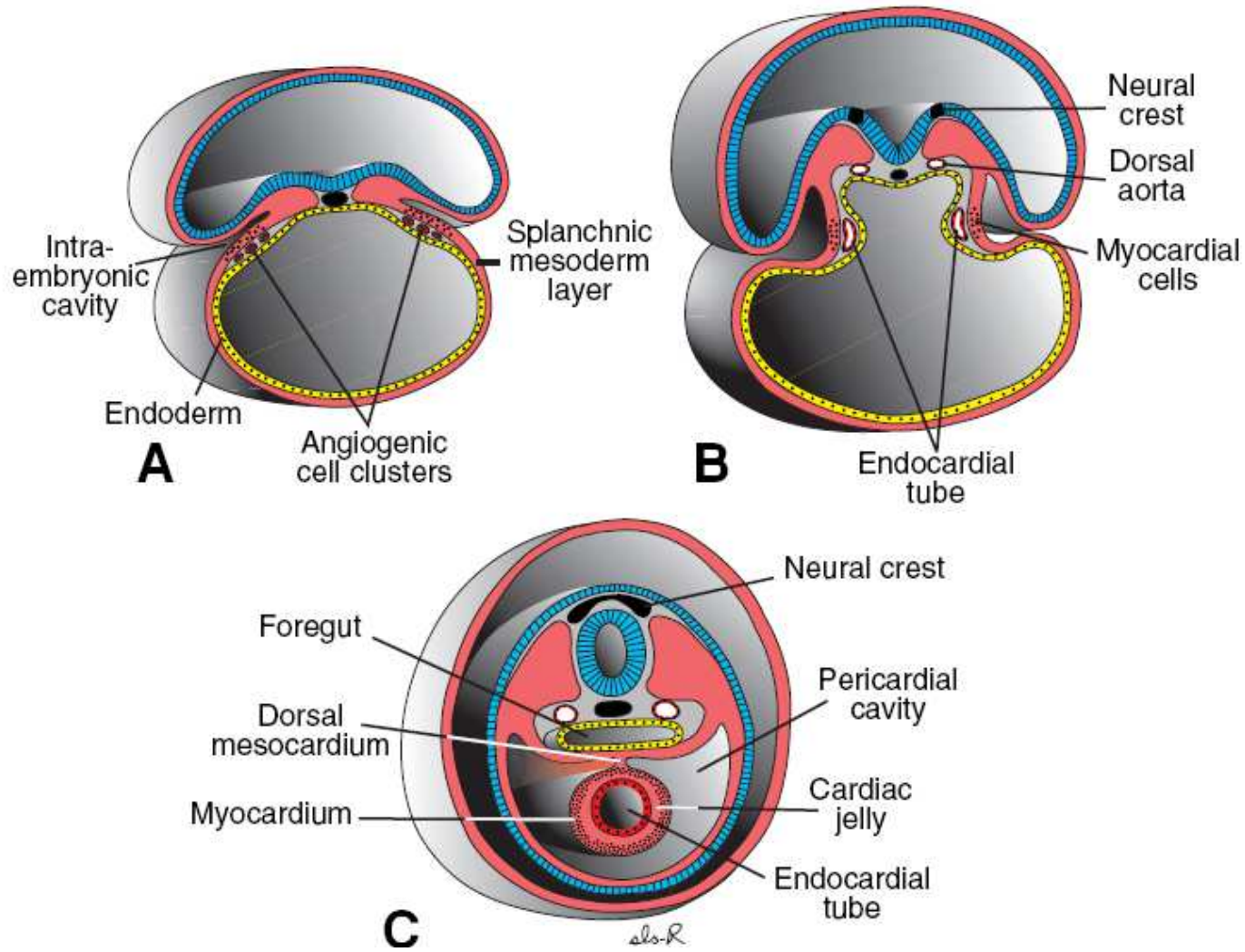
1- It invades the pericardial sac from its dorsal aspect dividing it into a visceral and a parietal layer.

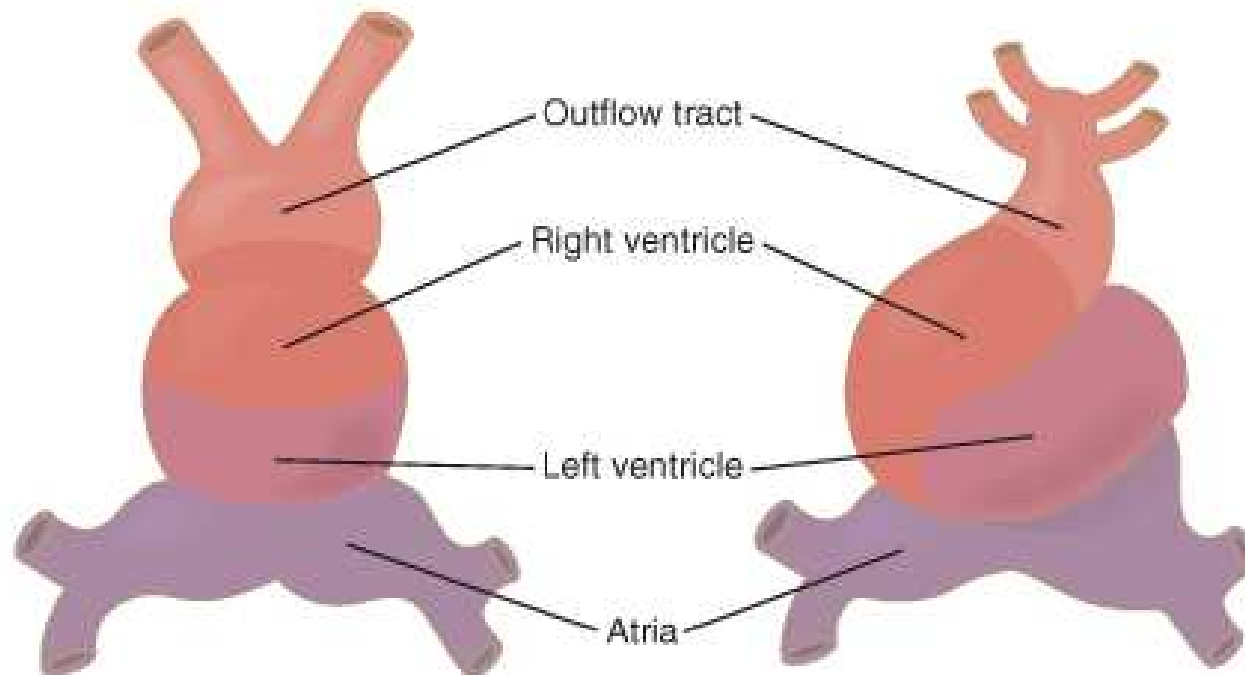
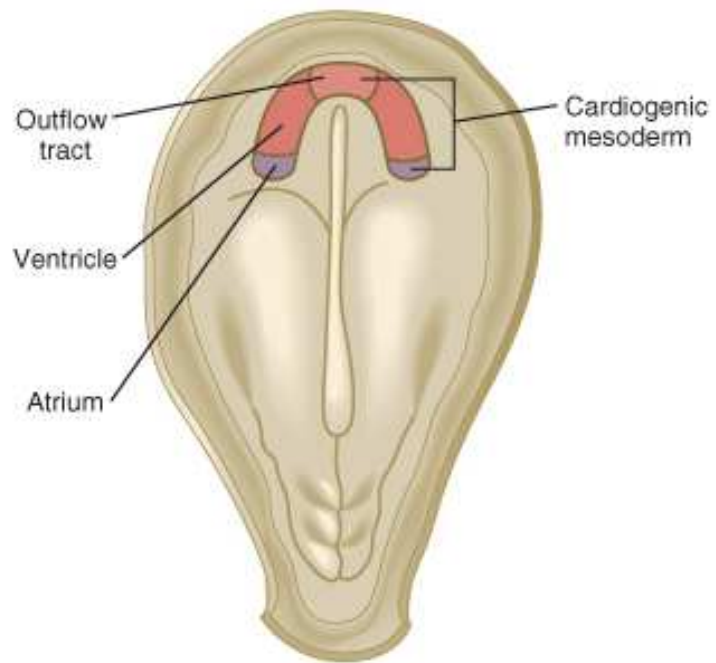
A dorsal mesocardium is attached to the dorsum of the tube which later becomes absorbed forming the transverse sinus of the heart.

2- The tube is divided into 4 chambers:

- Bulbus cordis.**
- Ventricle.**
- Atrium.**
- Sinus venosus.**

The constriction between the atrium and ventricle is elongated and is called atrio-ventricular canal.





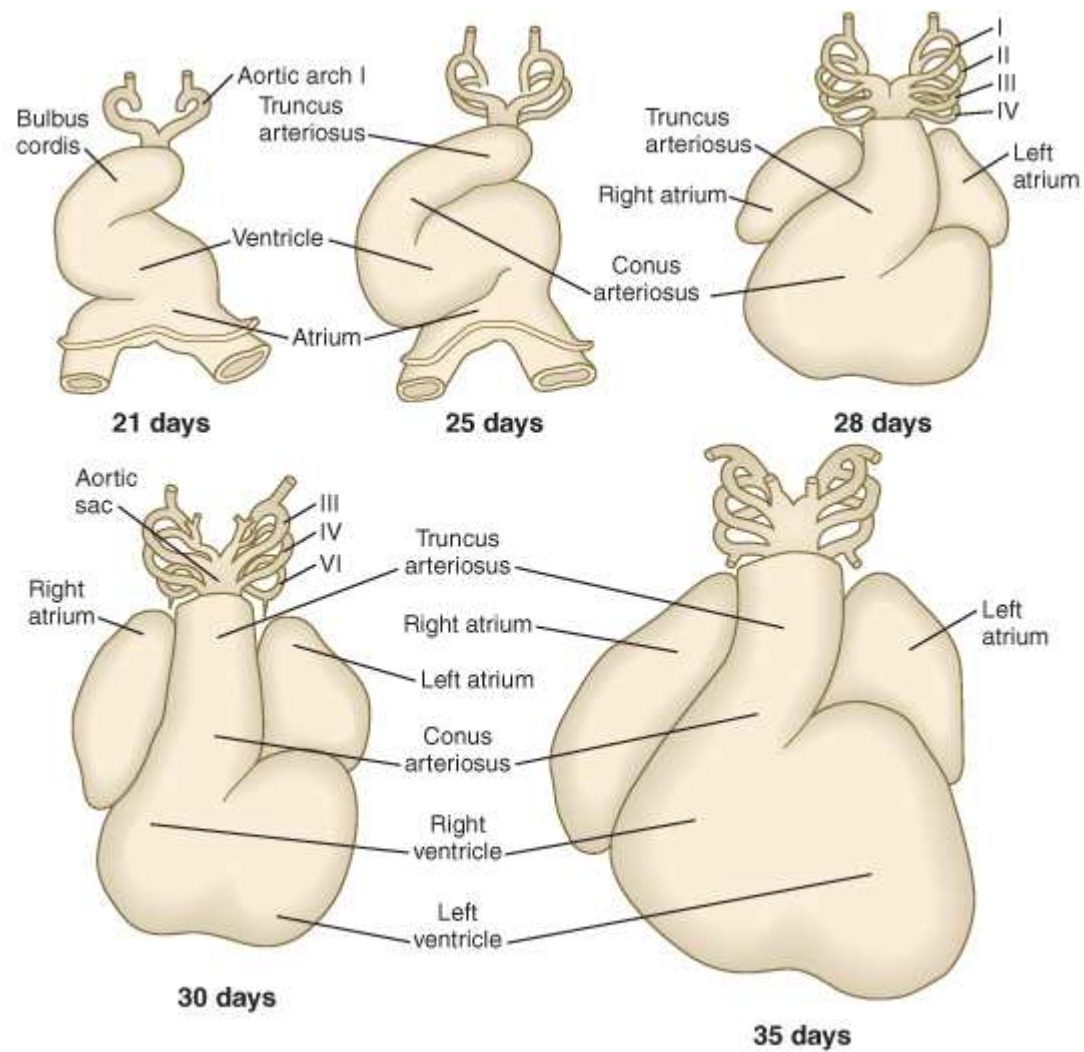
3- Formation of U- shaped heart tube: the heart tube grows faster than pericardium. So, it becomes folded to form U-shaped tube.

4- Formation of S-shaped heart tube: resulting in

- Bulbus cordis lies anterior and to the right.**
- ventricle lies anterior and to the left of the atrium.**
- Sinus venosus lies behind the atrium.**

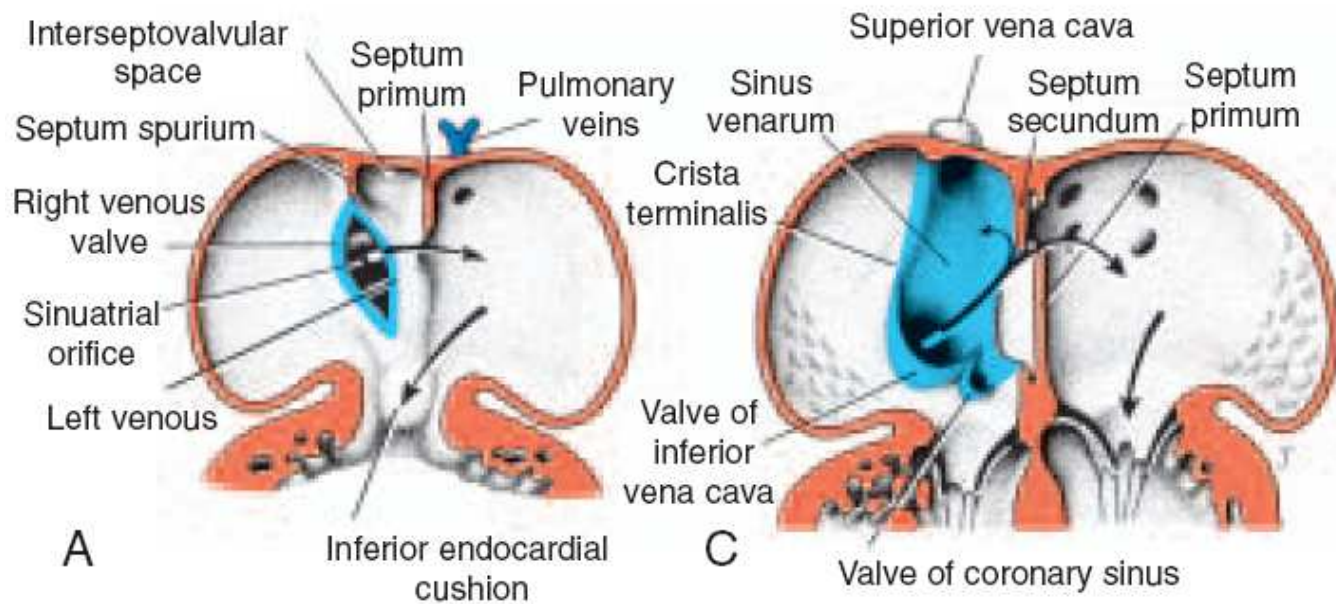
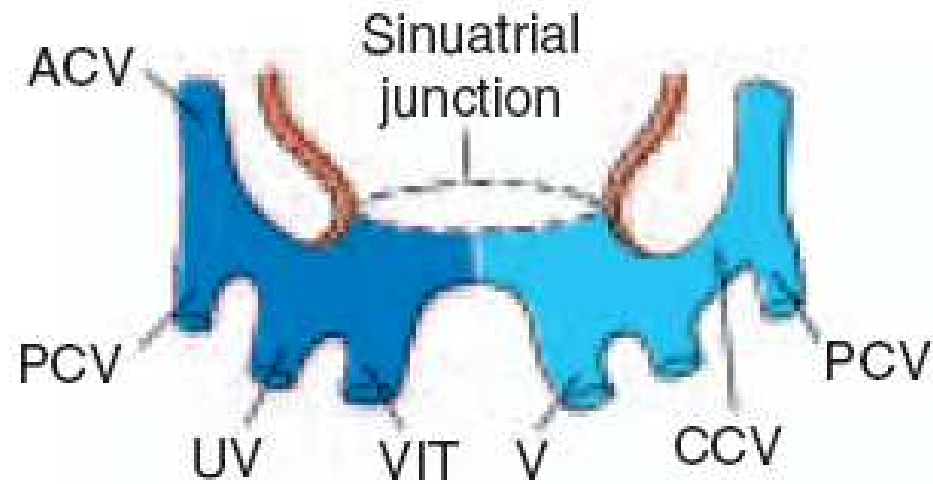
Bulbus cordis will give rise to:

- Proximal 1/3 will form trabeculated part of right ventricle.**
- Mid part (conus cordis) will form outflow tracts of both ventricles.**
- Distal part (truncus arteriosus) will form the roots and proximal portion of the aorta and pulmonary artery.**



The Sinus Venosus:

- It opens into the centre of the dorsal wall of the common atrium.
- It is formed of a body and 2 horns (right & left).
- Each horn receives 3 veins:
 - 1- Umbilical V.
 - 2- Vitelline V.
 - 3- Common cardinal V.
- The opening between the sinus venosus and the right atrium has the shape of vertical slit, its edges are called rt. and Lt. venous valves(sino-atrial valves). They fuse together cranially forming **septum spurium**.

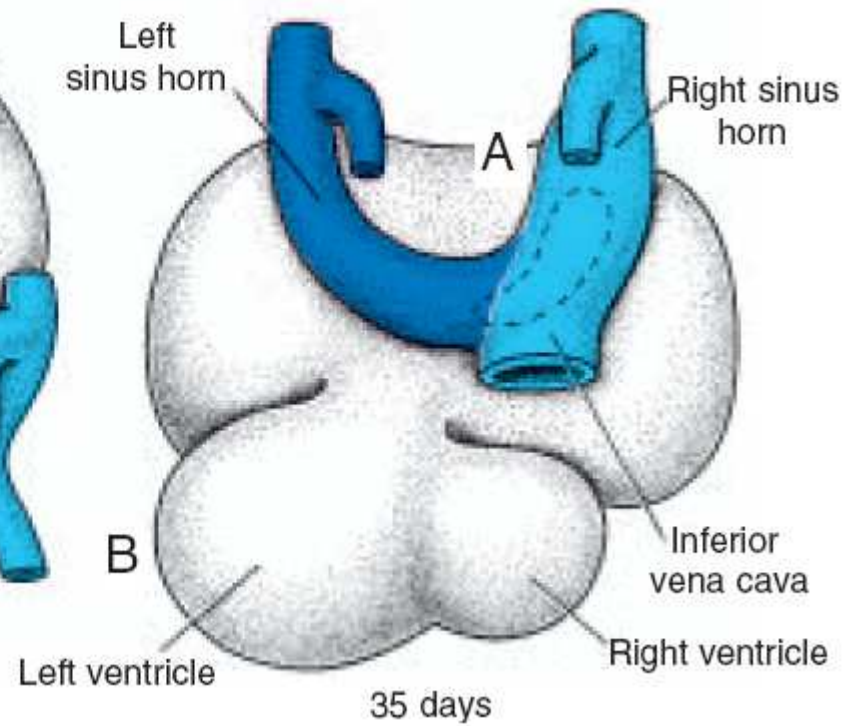
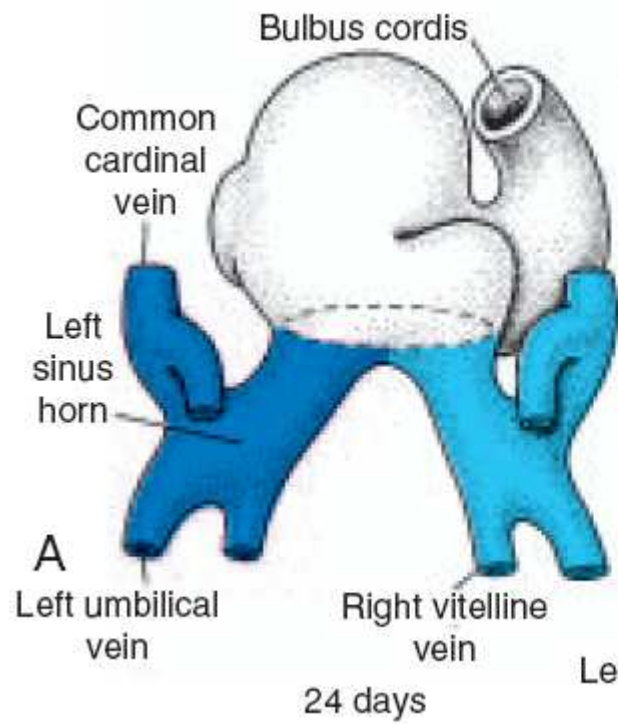


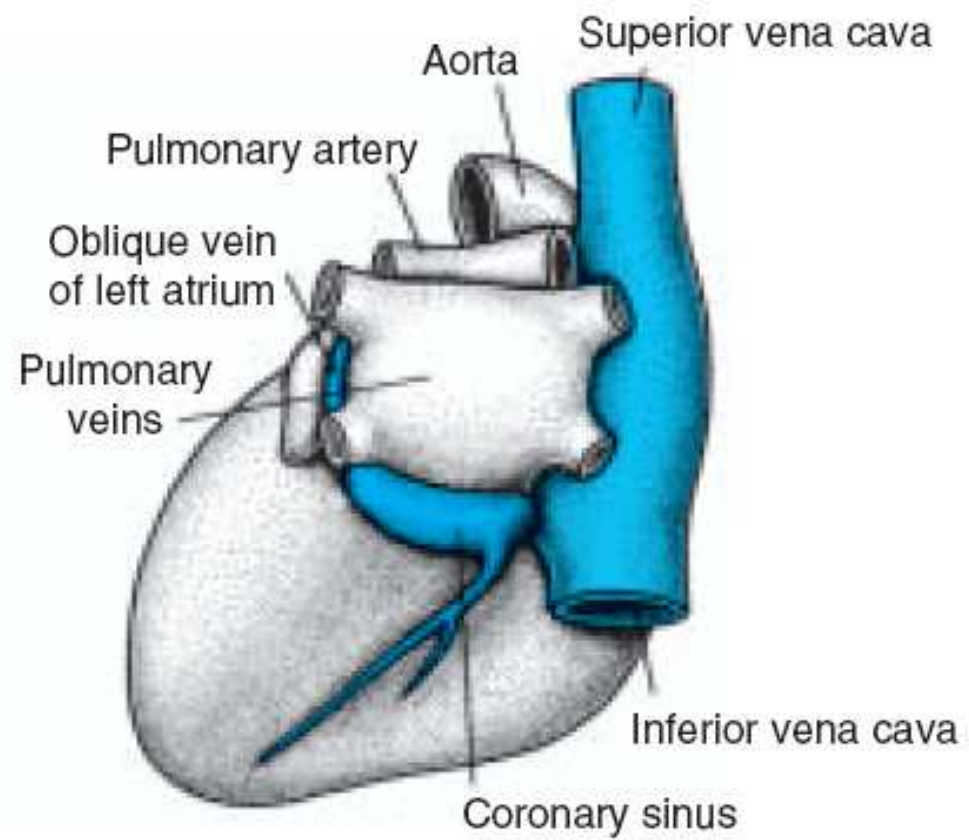
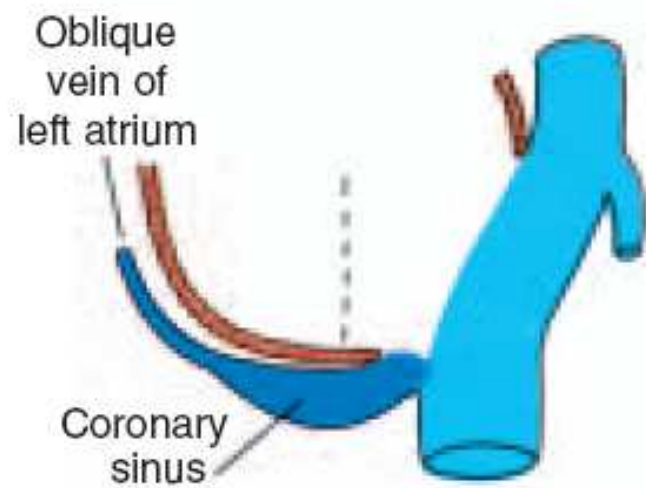
Fate of the sinus venosus:

- **As the result of left to right shift of venous blood, the Rt. Horn enlarges while the body and left horn diminishes.**
- **The sino- atrial orifice shifts to the right and opens in the part of atrium that will form the Rt. Atrium.**
- **The Rt. Horn is incorporated into the Rt. Atrium giving the smooth posterior part called sinus venarum.**
- **The body and Lt. horn form the coronary sinus.**
- **The upper part of Rt. venous valve give crista terminalis.**

The lower part of Rt. venous valve give valve of IVC and of coronary sinus.

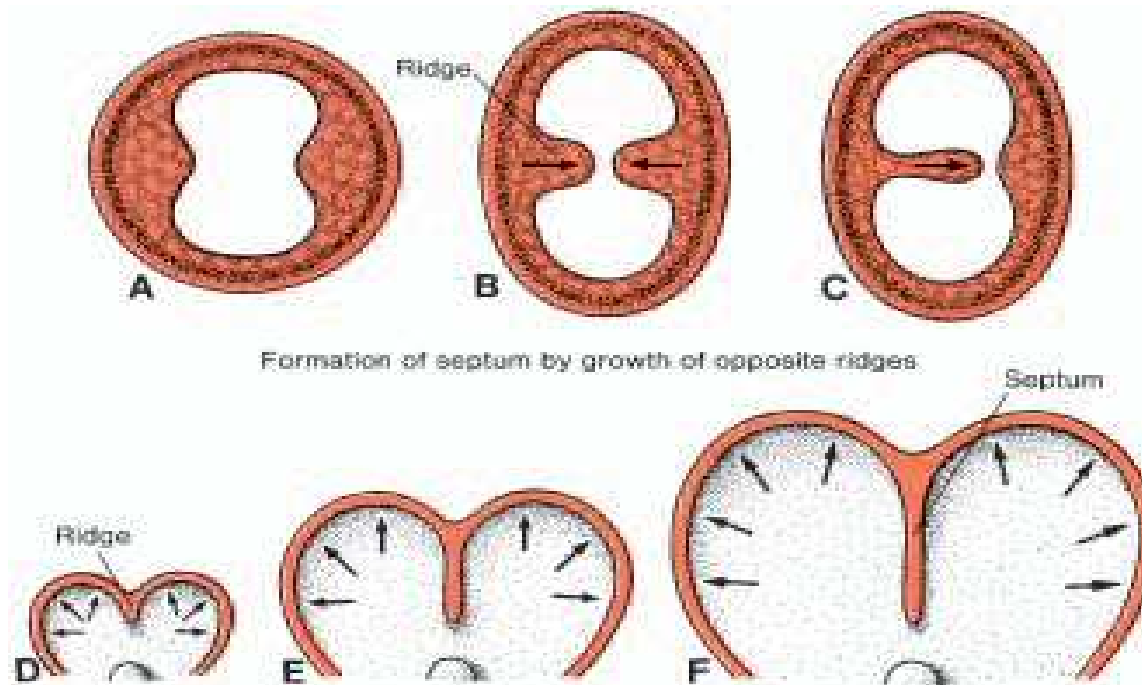
The Lt. venous valve enters in the formation of the inter-atrial septum.





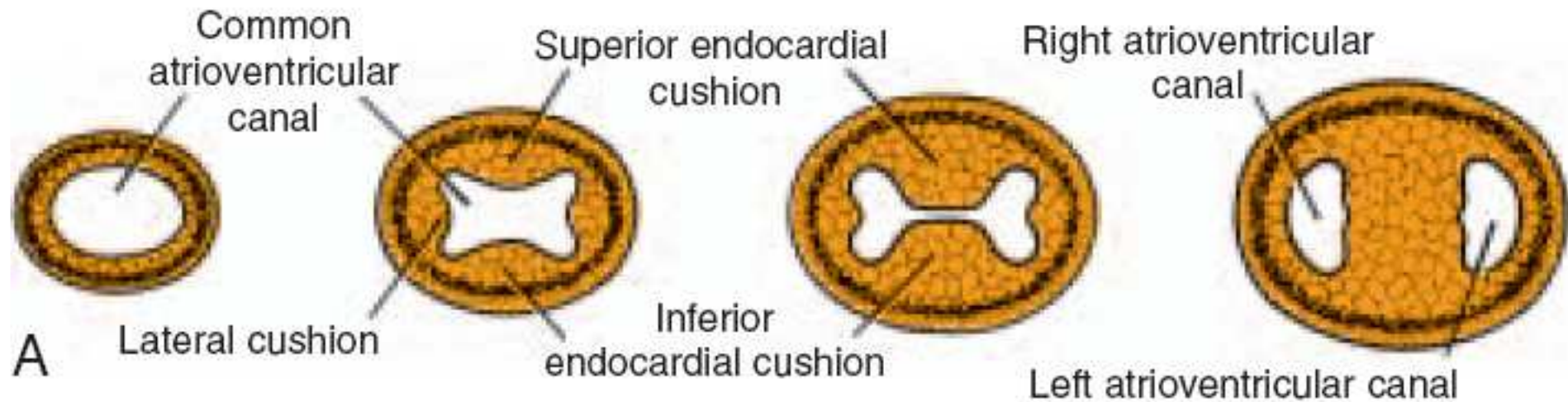
Formation of the cardiac septa:

- The major septa are formed between the 27th & 37th days.
- They are formed by 1 of 2 methods:
 - 1- 2 actively growing masses of tissue that approach each others until they fuse dividing the lumen into 2 canals.
 - 2- active growth of a single tissue mass that continue to expand until it reaches the opposite side of the lumen.



Septum Formation in the Atrio- Ventricular Canal:

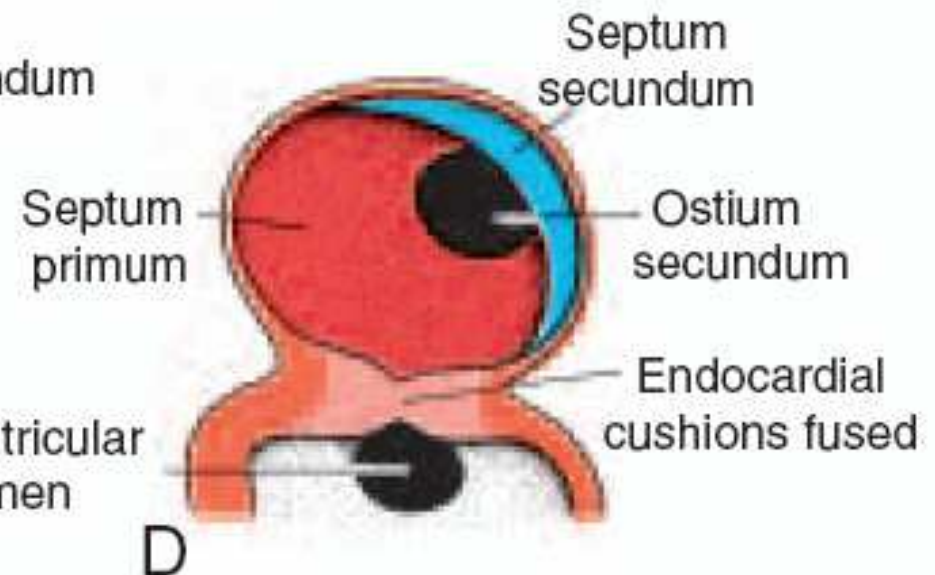
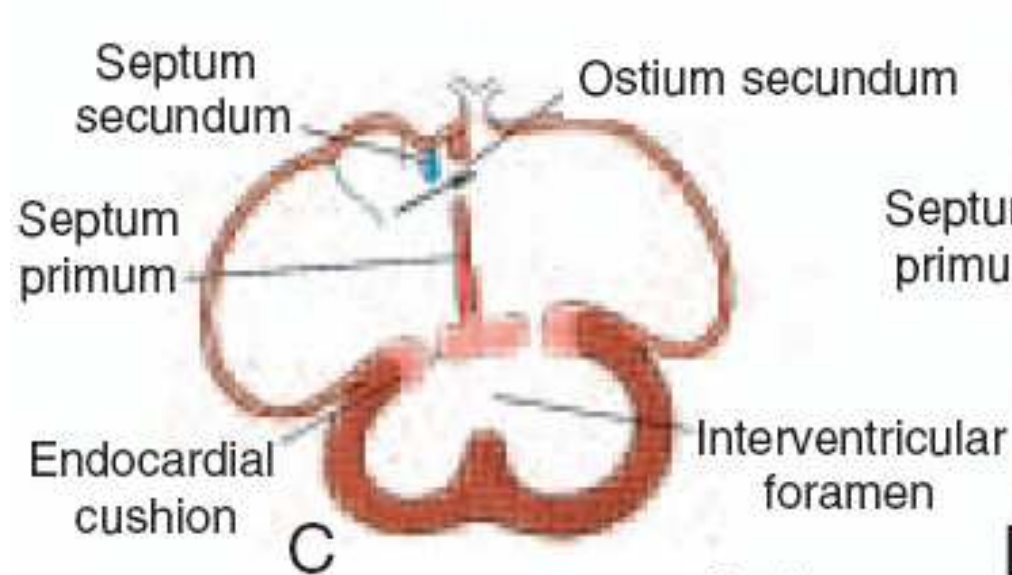
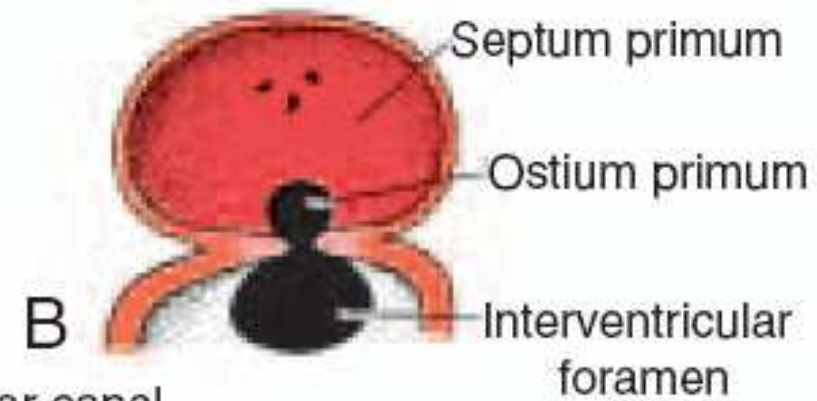
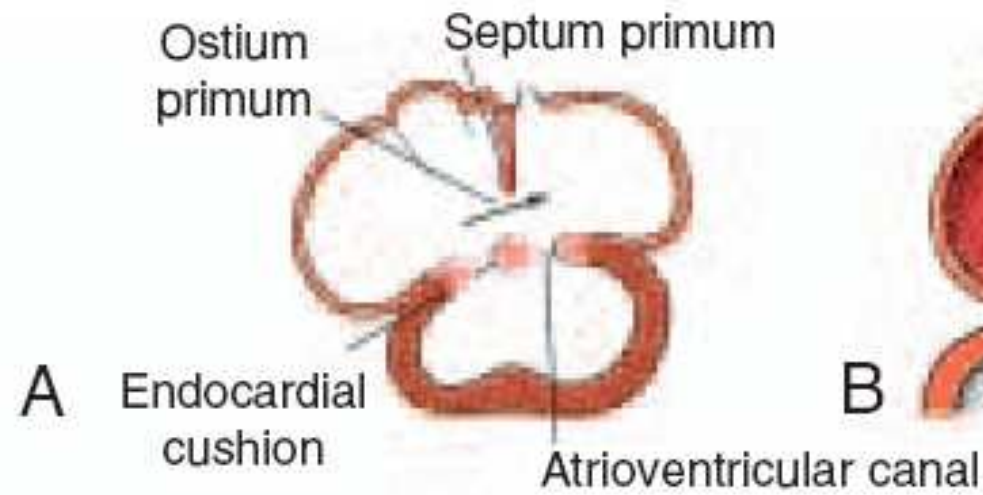
- Two endocardial cushions, ventral & dorsal (= superior and inferior) project from the ventral and dorsal walls of the canal.
- They meet and fuse together forming the septum intermedium which divides the canal into rt. & Lt. parts.



Septum Formation in the Common Atrium:

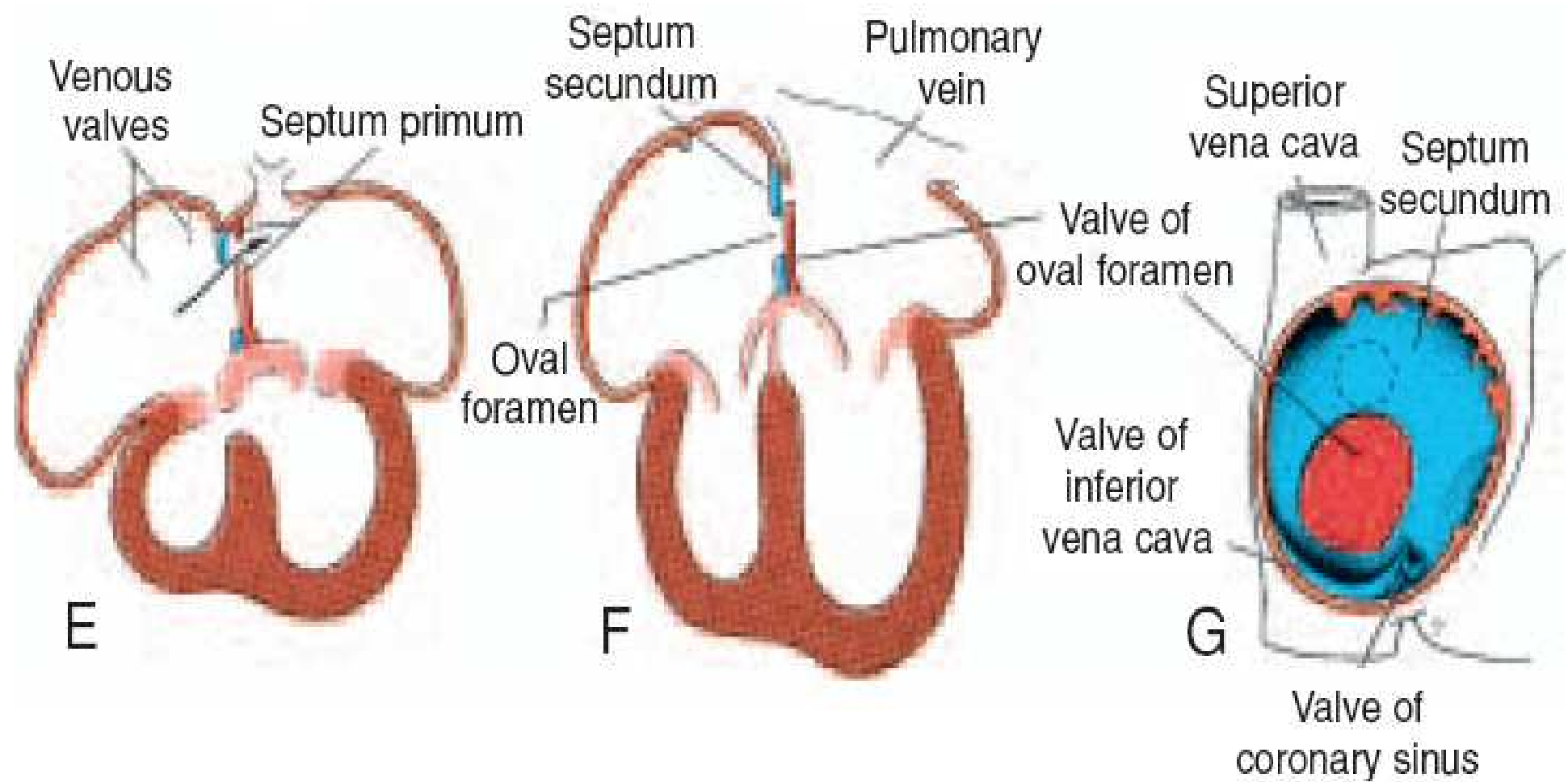
1- The Septum Primum:

- It is a membrane which grows from the dorso-cranial wall of the atrium.
- It descends towards the septum intermedium but is separated from it by the **foramen primum (ostium primum)**.
- The foramen primum becomes progressively smaller and is finally closed.
- Before complete closure, the septum primum ruptures in its center forming the **foramen secundum**.



2- The septum secundum:

- A thick crescentic membrane that grows from the ventro-cranial wall of the atrium to the rt. Side of the septum primum. The opening below it is called the foramen ovale.**
- It reaches down to the ventral endocardial cushion.**
- So , blood in the rt. Atrium passes to the Lt. atrium via s- shaped course through the foramen ovale and foramen secundum. But movement in the opposite direction is prevented by flap- like valvular action of the remaining lower part of septum primum closing foramen ovale.**
- After birth, pressure in both atria becomes equal and the 2 septa fuse. The septum primum in the site of foramen ovale will form fossa ovalis and the margins of septum secundum form limbus fossa ovalis (annulus ovalis).**



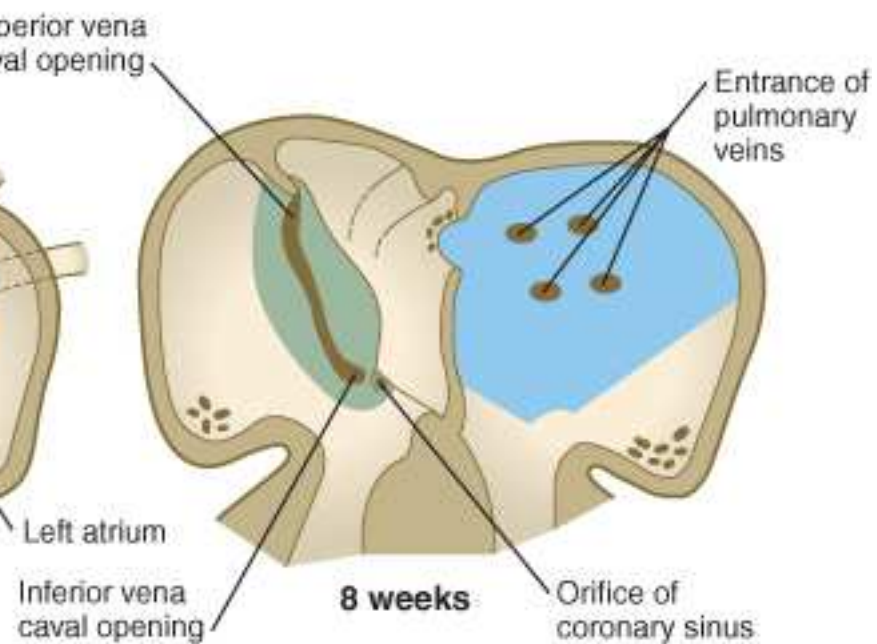
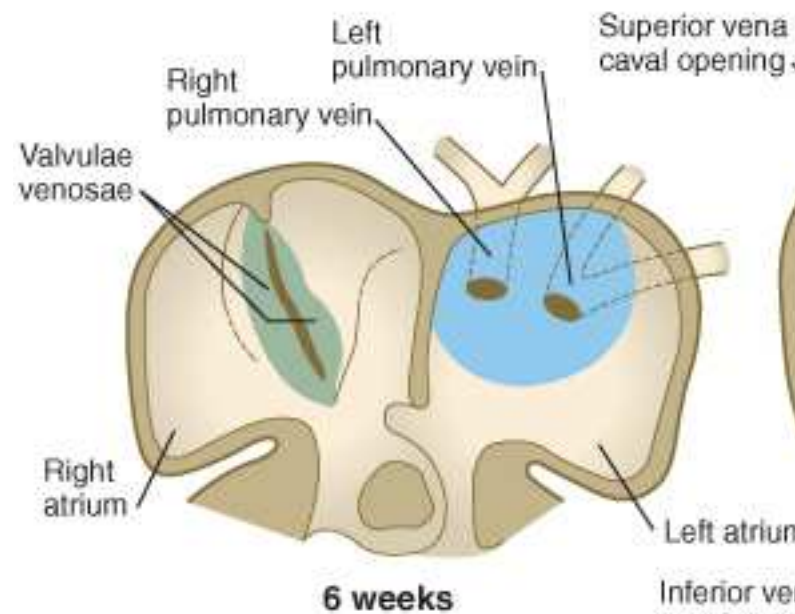
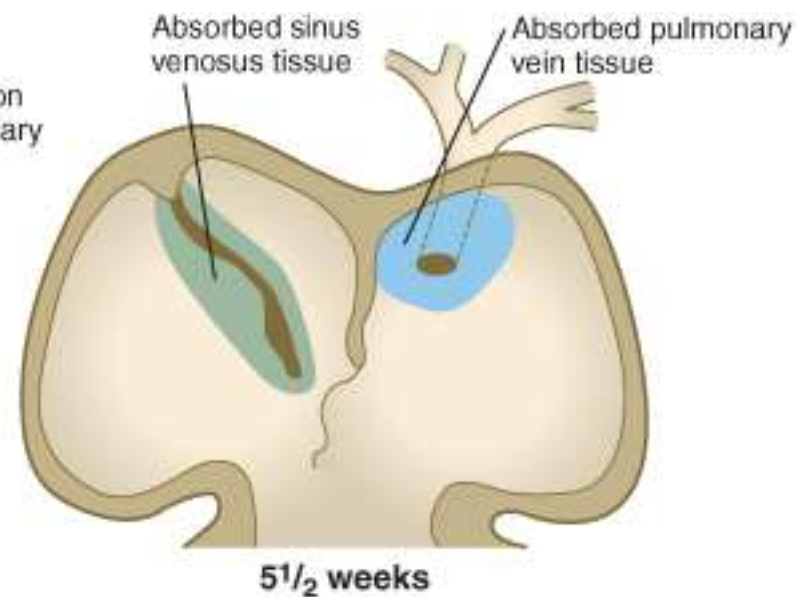
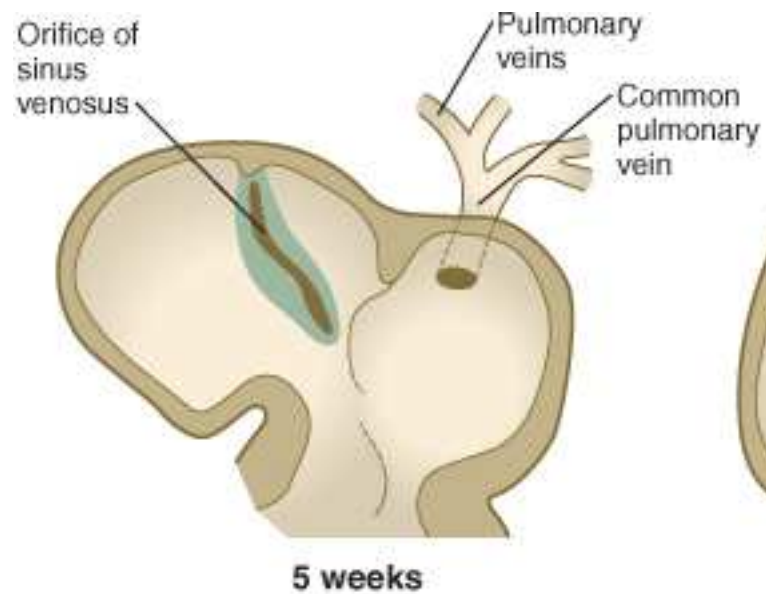
Development of the right atrium:

The Rt. atrium is developed from:

- 1- The right half of the common atrium (the anterior rough part).**
- 2- The absorbed rt. horn of sinus venosus (the posterior smooth part – sinus venarum)**
- 3- The upper part of the rt. atrio-ventricular canal.**

Development of the left atrium:

- The left atrium receives a common pulmonary vein which is formed by the union of 4 pulmonary veins.**
- The proximal part of this venous system is absorbed into the wall of the developing left atrium form the smooth part.**
- The left half of the common atrium form the rough part.**
- The upper part of the left atrio-ventricular canal.**

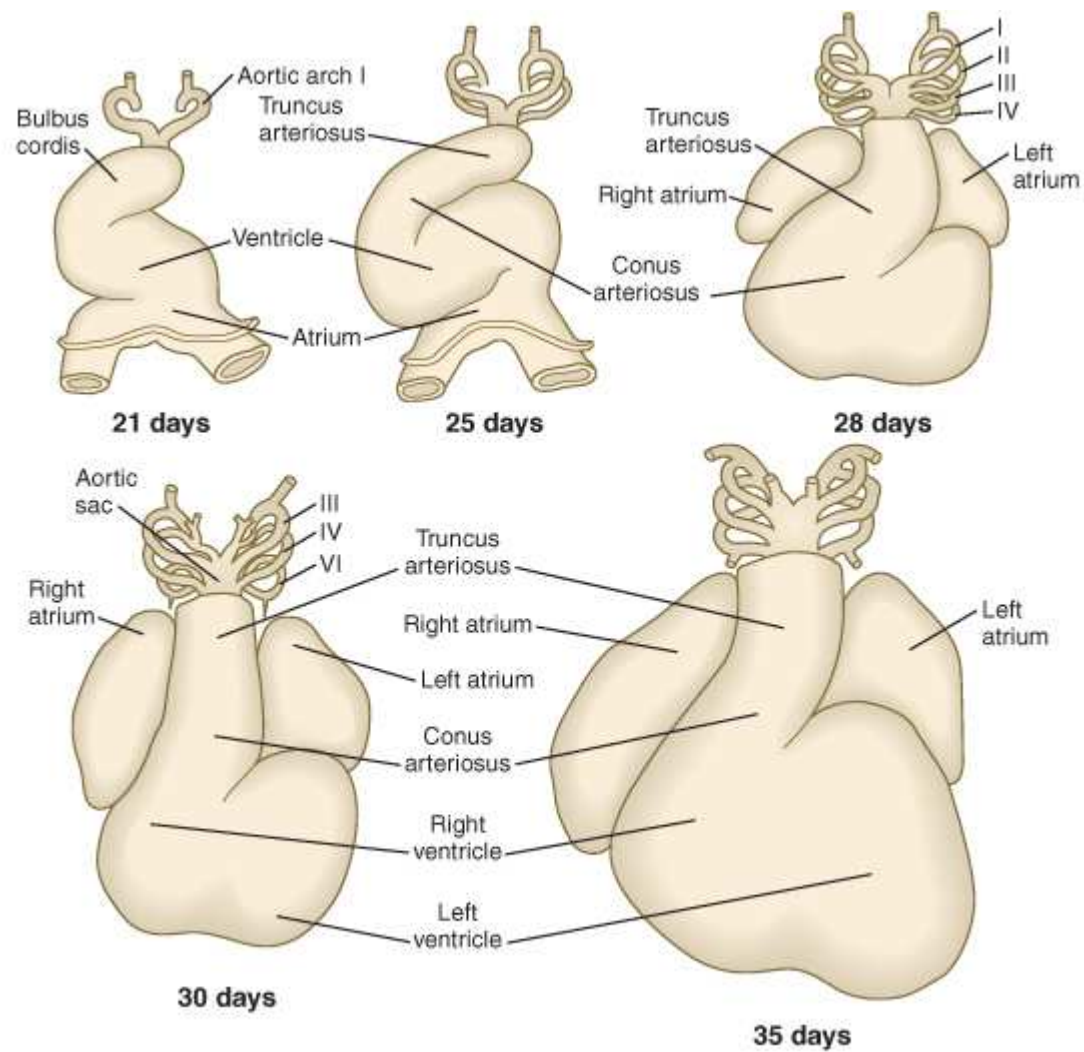


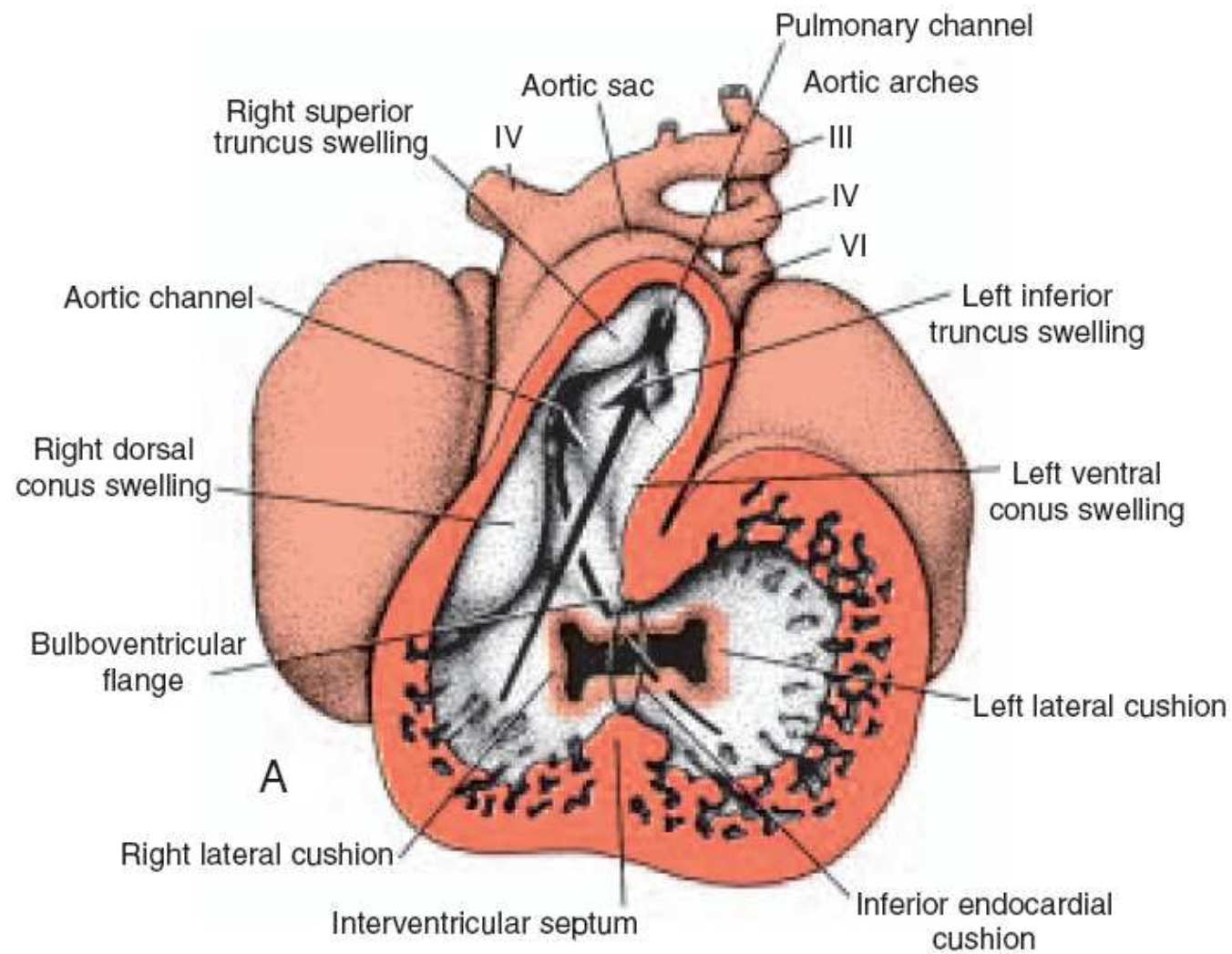
Development of the bulboventricular region:

- At first, the bulbus cordis lies to the rt. side of the common ventricle with a deep sulcus between them.
- Gradually, this sulcus is obliterated and the proximal part of the bulbus cordis becomes absorbed inside the ventricle to form the common bulbo-ventricular chamber.

Fate of bulbus cordis:

- Its proximal part: forms the trabecular part of rt. Ventricle.
- Its middle part (conus cordis) : is divided by a septum (conus septum) into the infundibulum of the rt. ventricle and the vestibule of the Lt.ventricle.
- Its distal part: becomes divide by spiral septum into pulmonary trunk and ascending aorta.





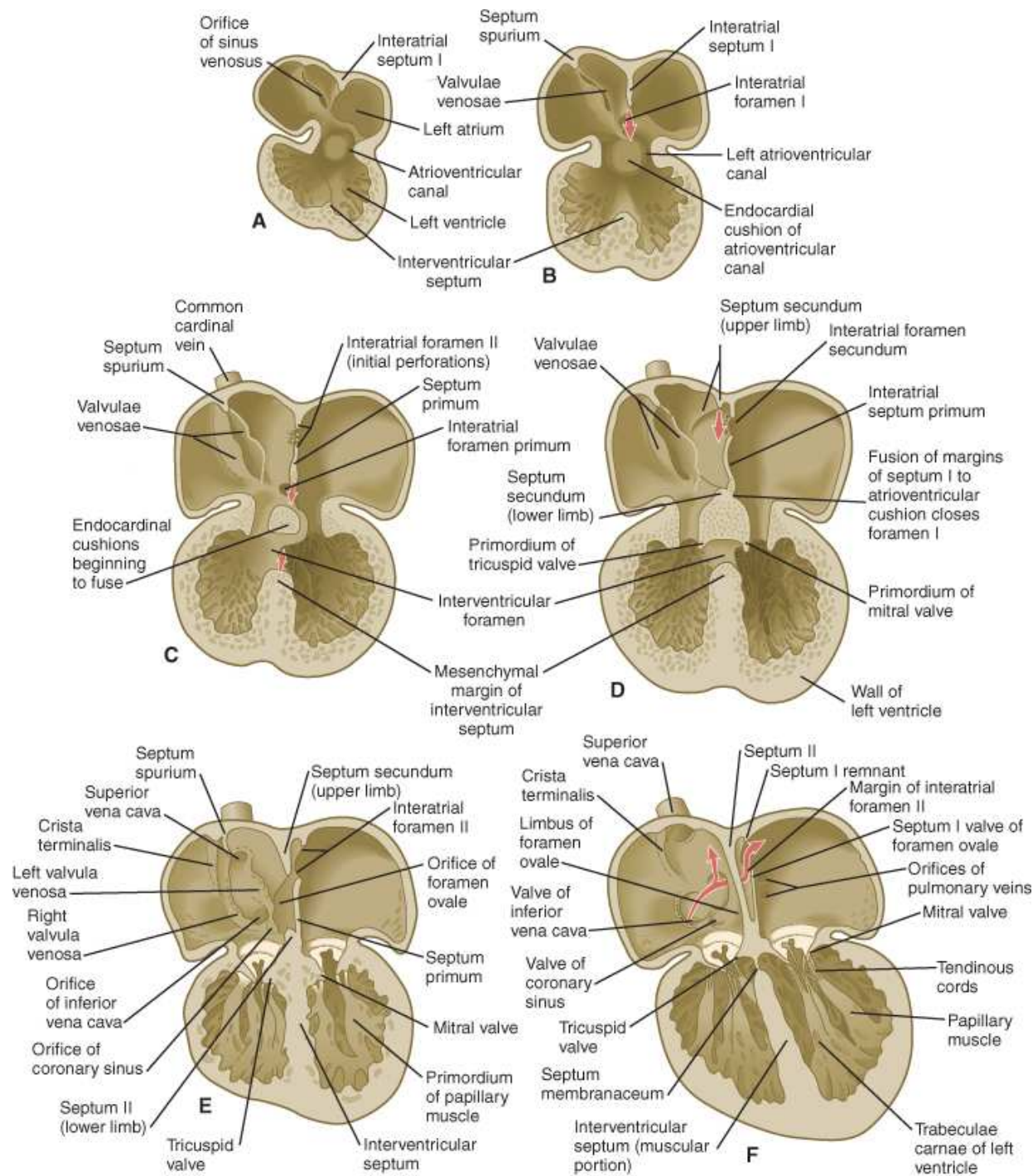
Development of the ventricles:

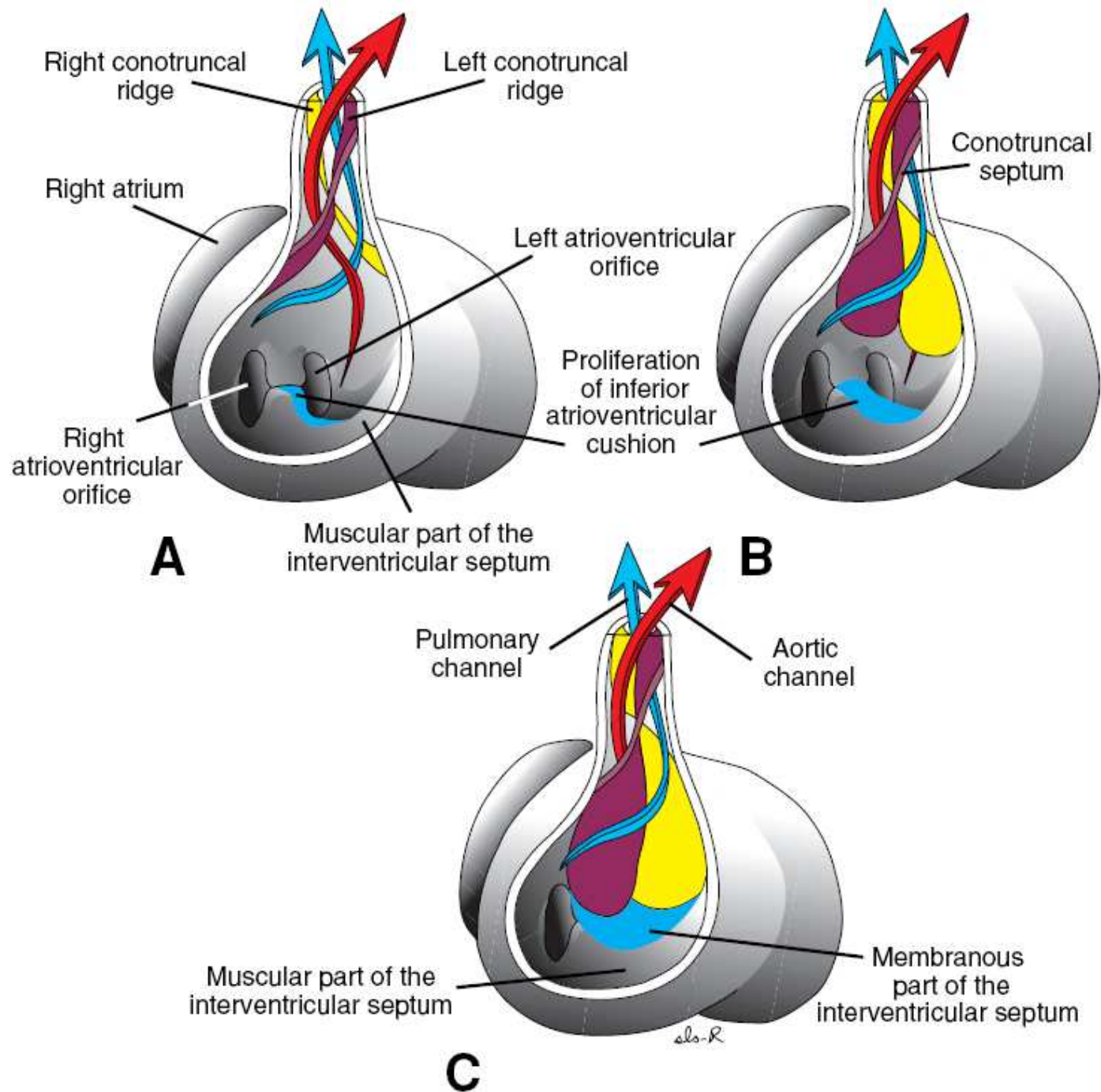
- The lower part of the bulbus cordis and the common ventricle form together the bulboventricular chamber.

- This chamber becomes divide by the interventricular septum which is formed of 2 parts:

- 1- Muscular part: which grows as a crescentic ridge from the floor of the chamber with a free concave upper edge.

- 2- Membranous part: which grows from the inferior atrio-ventricular endocardial cushion and the conus septum to fill the gap between the upper border of the muscular part and the septum intermedium.



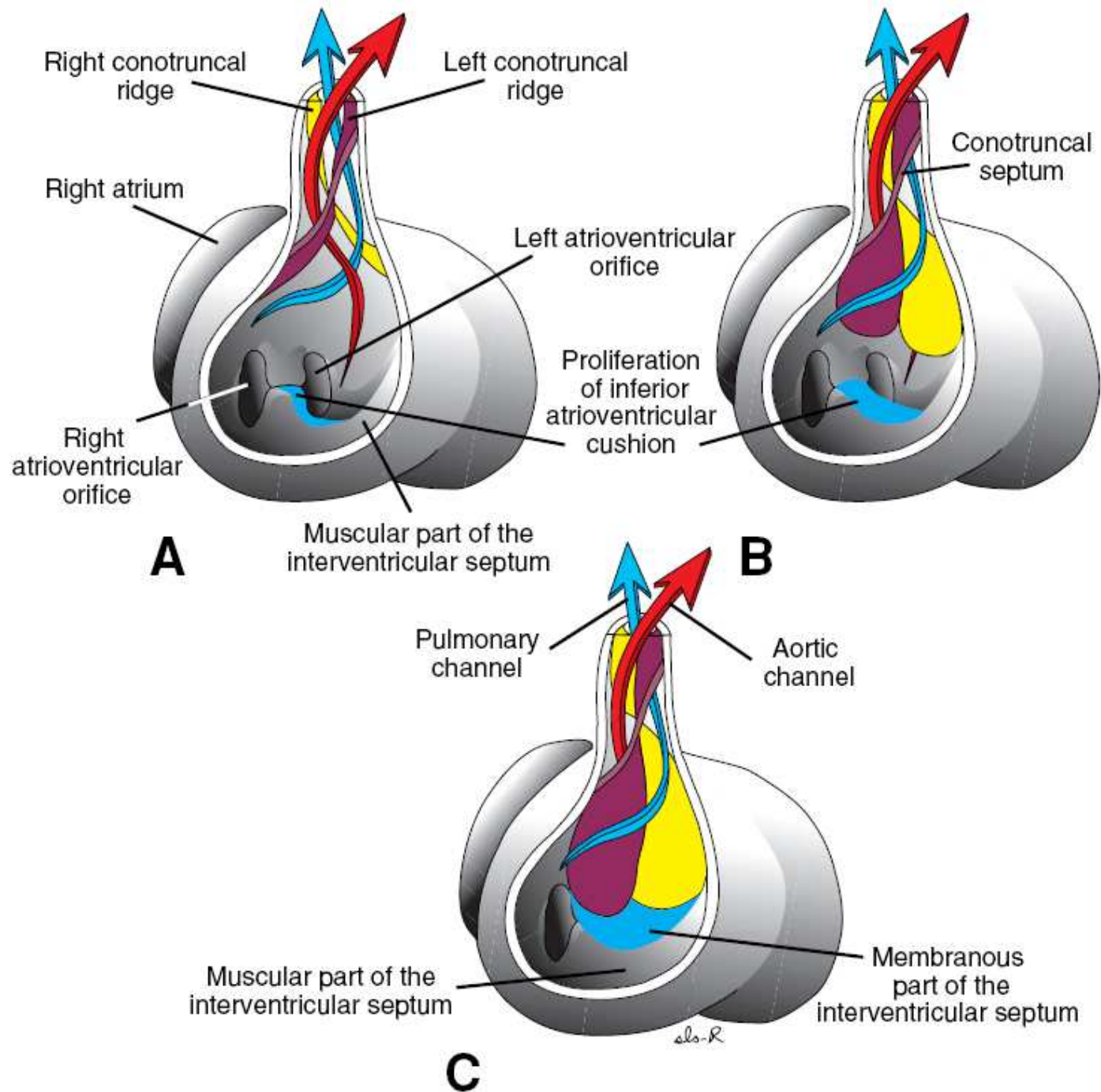


- The right ventricle is derived from:
 - 1- Rt. $\frac{1}{2}$ of the bulbo-ventricular chamber (the rough inflowing part).
 - 2- The middle part of the bulbus cordis (the smooth outflowing part –the infundibulum).

- The left ventricle is derived from:
 - 1- Lt. $\frac{1}{2}$ of the bulbo-ventricular chamber (the rough inflowing part).
 - 2- The middle part of the bulbus cordis (the smooth outflowing part – the vestibule).

Development of the aorta and pulmonary trunk:

- Two endocardial swellings (rt. Superior and Lt. inferior) develop in the distal part of the bulbus cordis (truncus arteriosus) and descend in the direction of the ventricles following a spiral course.
- later, they fuse together forming a spiral aortico-pulmonary septum dividing this part into ascending aorta and pulmonary trunk which are twisted on each others.



Anomalies of the heart:

Causes:

1- Genetic causes:e.g. Turner and Down Syndromes.

2- Environmental causes: e.g. german measles virus.

Types:

1- Abnormal position:

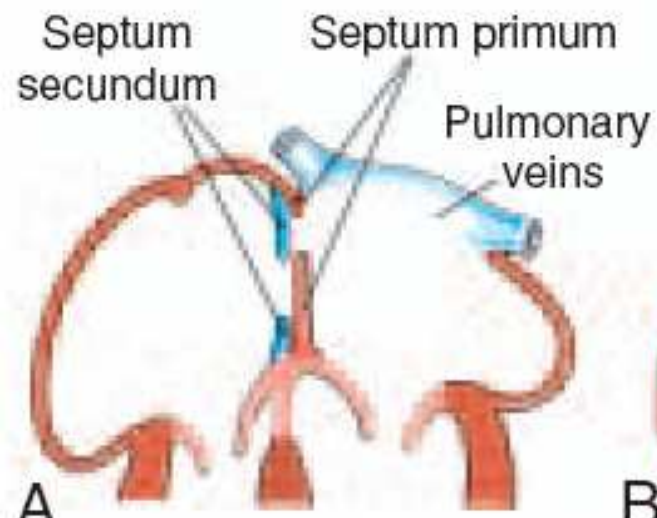
a- Dextrocardia: rt. Sided heart occurs alone or as a part of situs inversus totalis.

b- Ectopia cordis:the heart protrudes through a median gap in the chest wall.

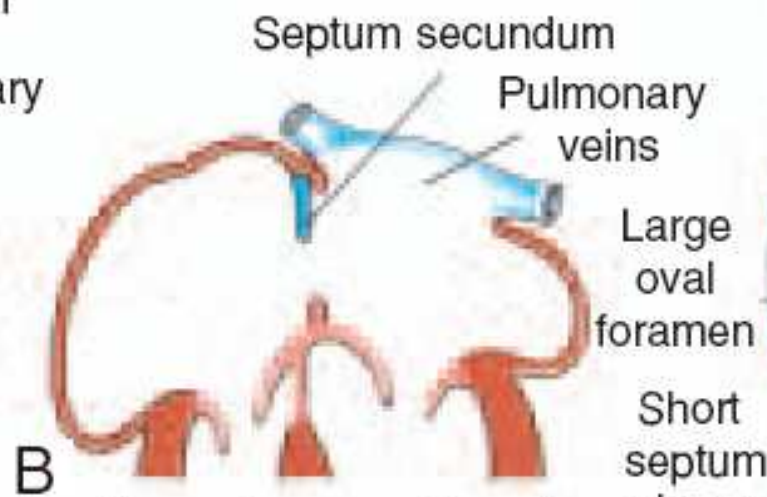
2- Septal problems:

a- Atrial septal defects: includes

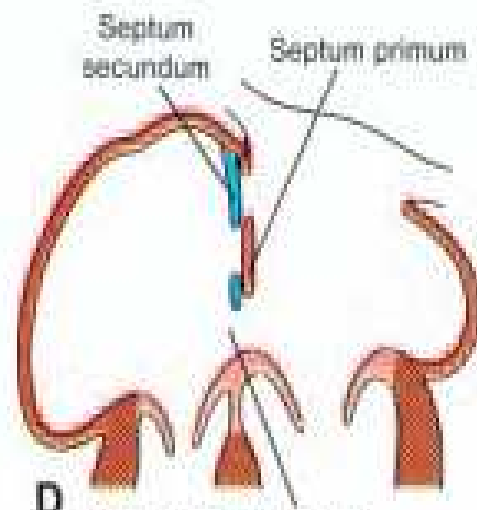
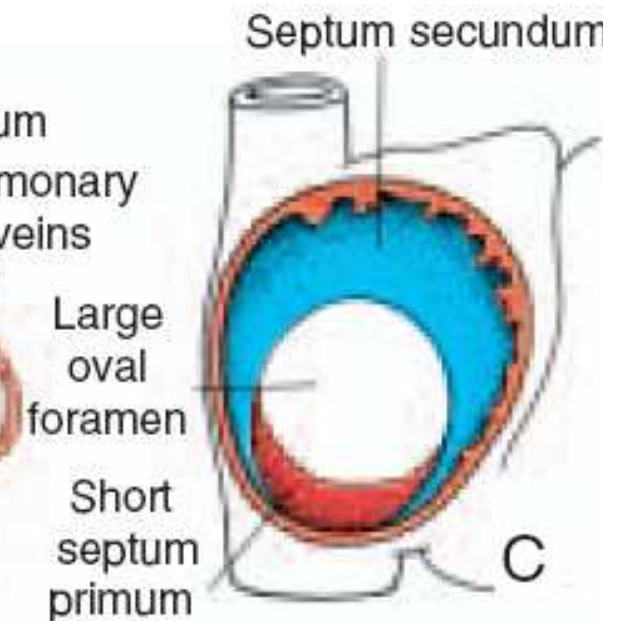
- Patent foramen ovale: a hole in the middle of the septum.**
- Ostium primum defect: a hole in the lower part of the septum.**
- Trilocular biventricular heart: failure of formation of the septum.**



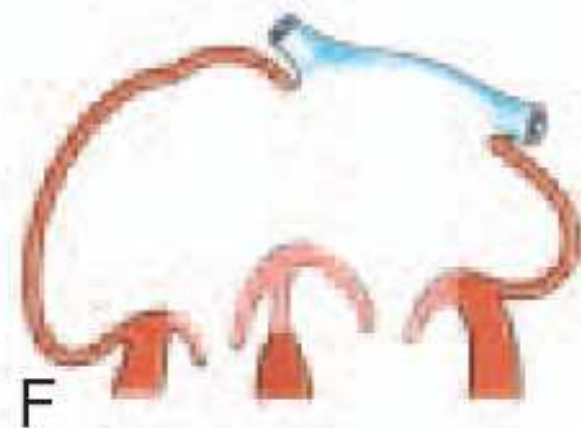
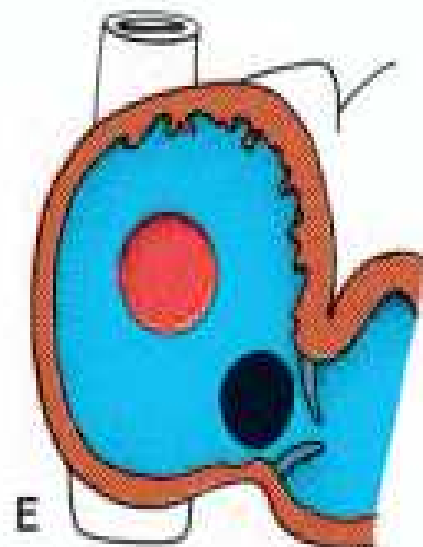
Normal septum formation



Excessive resorption of septum primum



Patent ostium primum



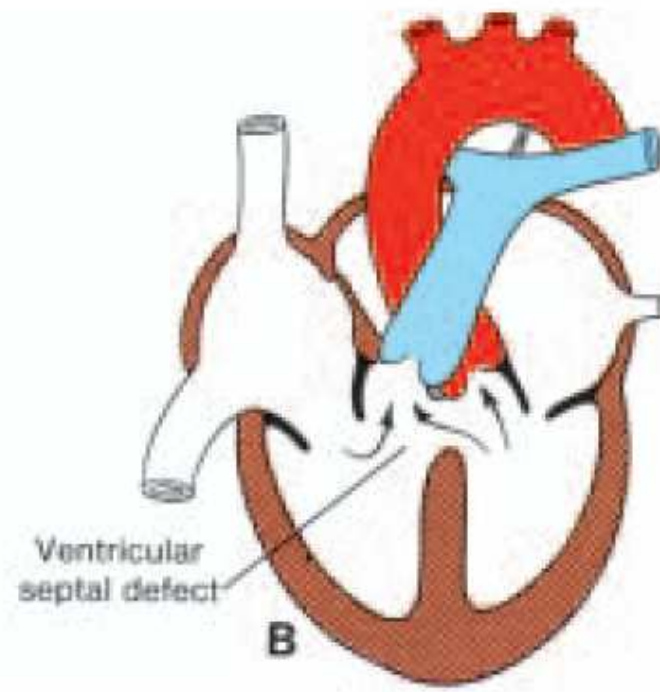
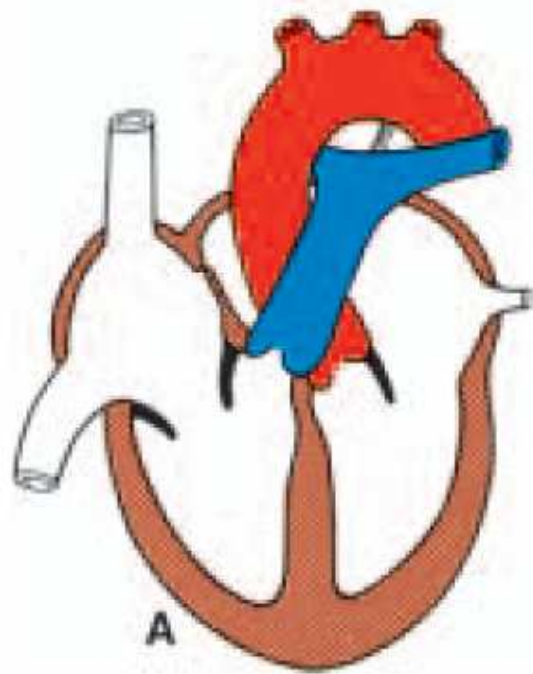
Absence of septum primum and septum secundum

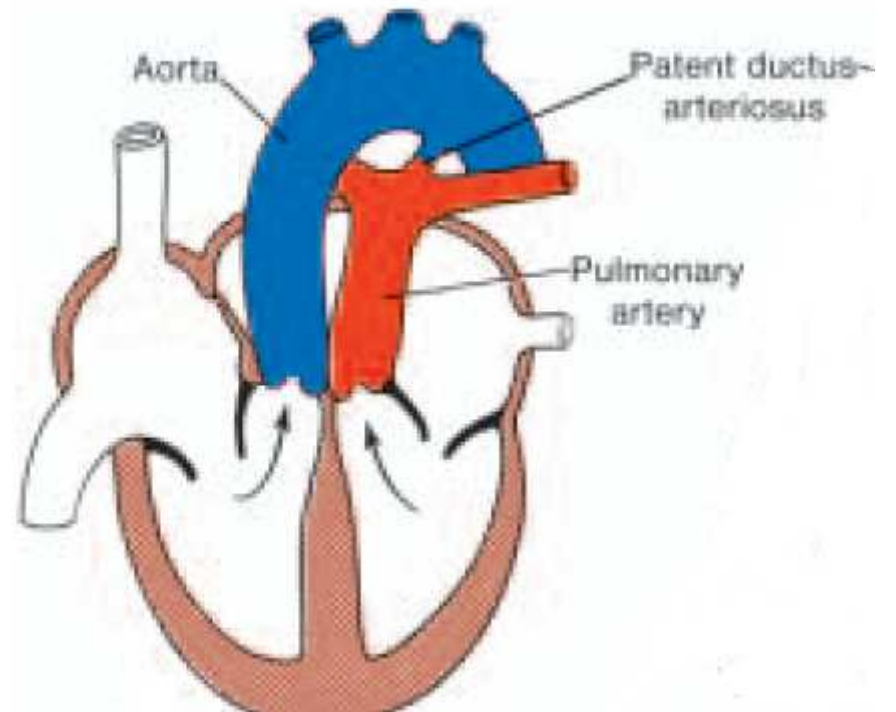
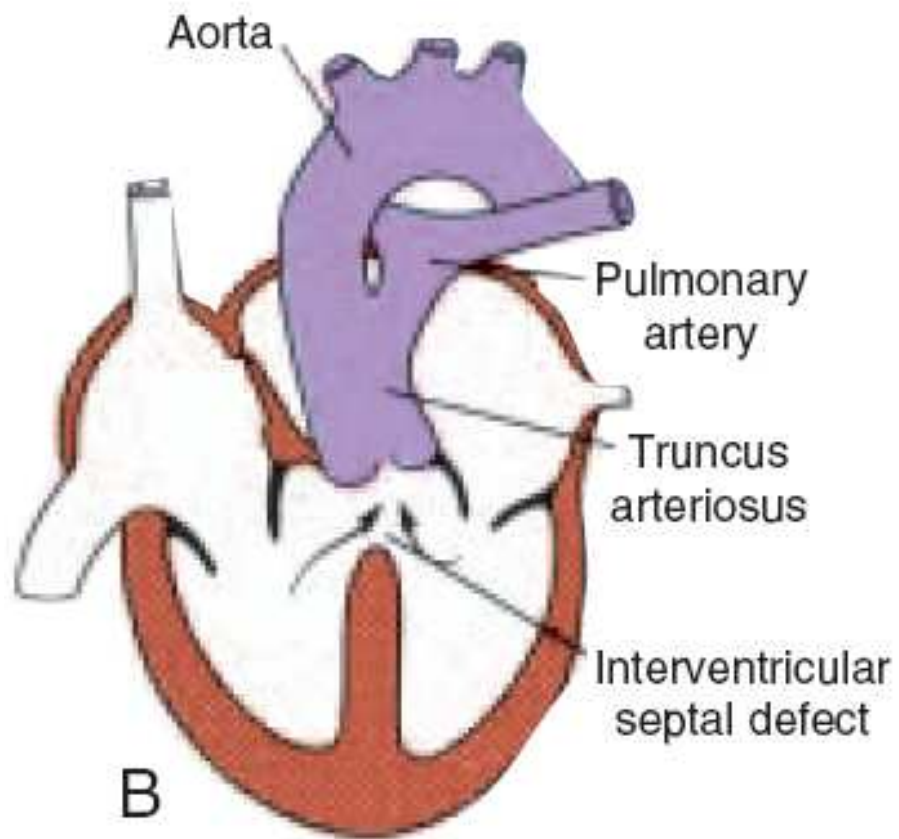
b- Ventricular septal defects (VSD):includes

- Membranous VSD (Roger's disease): persistence of interventricular foramen.**

c- Abnormal division of truncus arteriosus:

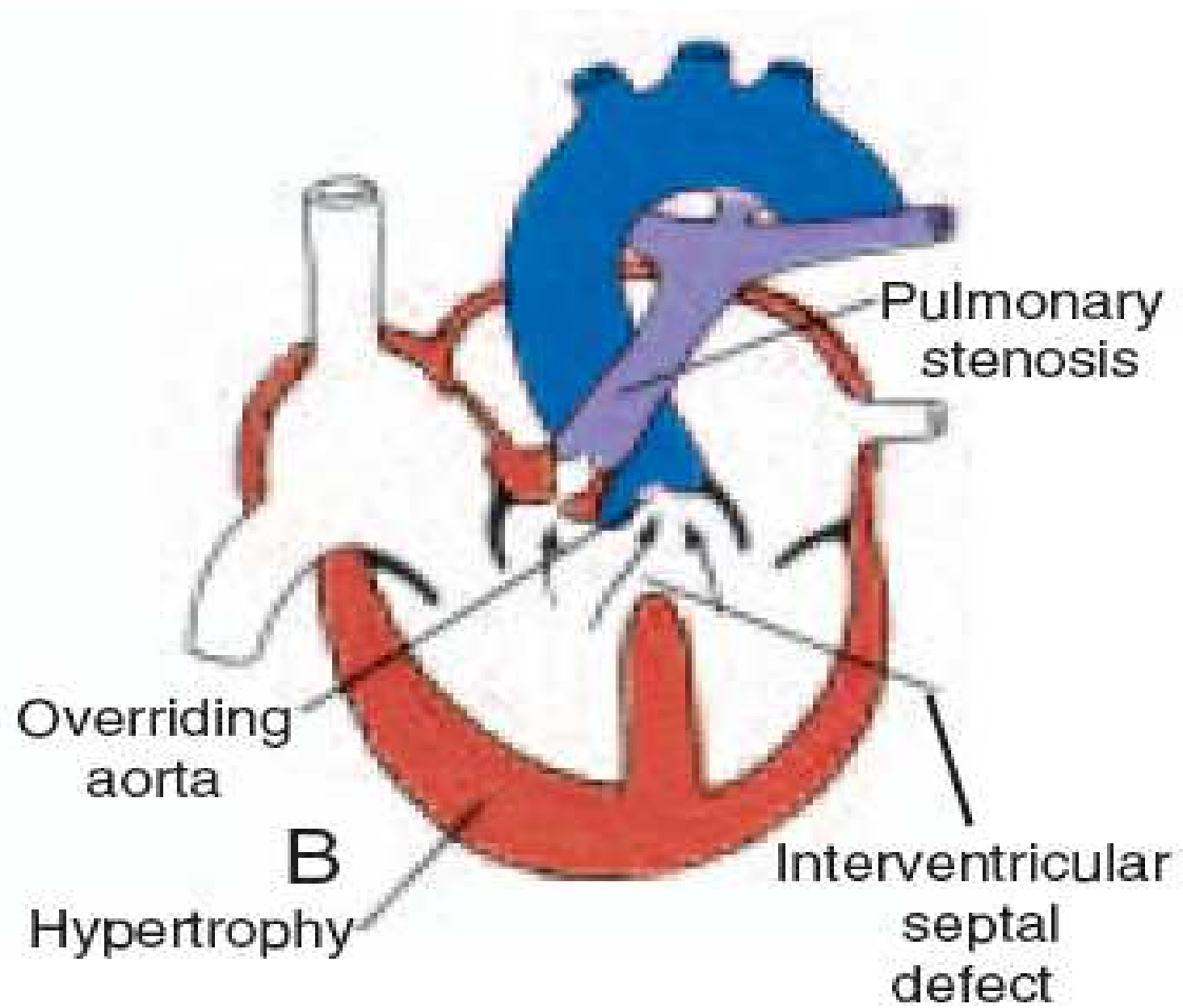
- Persistent truncus arteriosus: due to failure of the septum to develop.**
- Transposition of great vessels:aorta arises from rt. ventricle and pulmonary trunk from Lt. ventricle.**
- Congenital stenosis or atresia of pulmonary or aortic orifice.**





d- Fallot's Tetralogy:includes

- Pulmonary stenosis.**
- Hypertrophy of rt. Ventricle.**
- Membranous VSD.**
- Overriding of aorta on the ventricular septum receiving blood from both ventricles.**



DEVELOPMENT OF BLOOD VESSELS

Occurs by 2 mechanisms:

1- Vasculogenesis: vessels arise by coalescence of angioblasts.

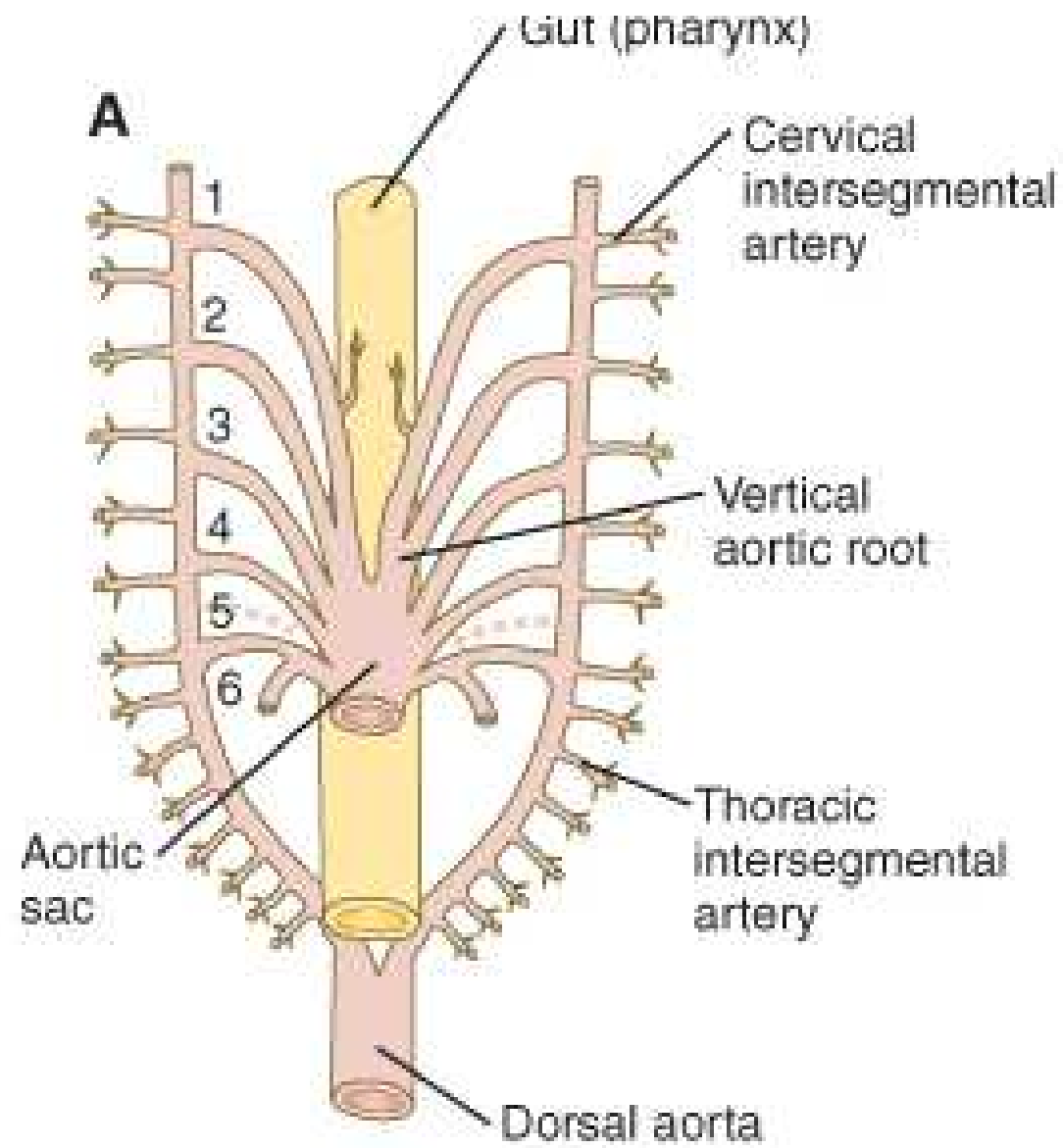
2- Angiogenesis: vessels sprout from existing vessels.

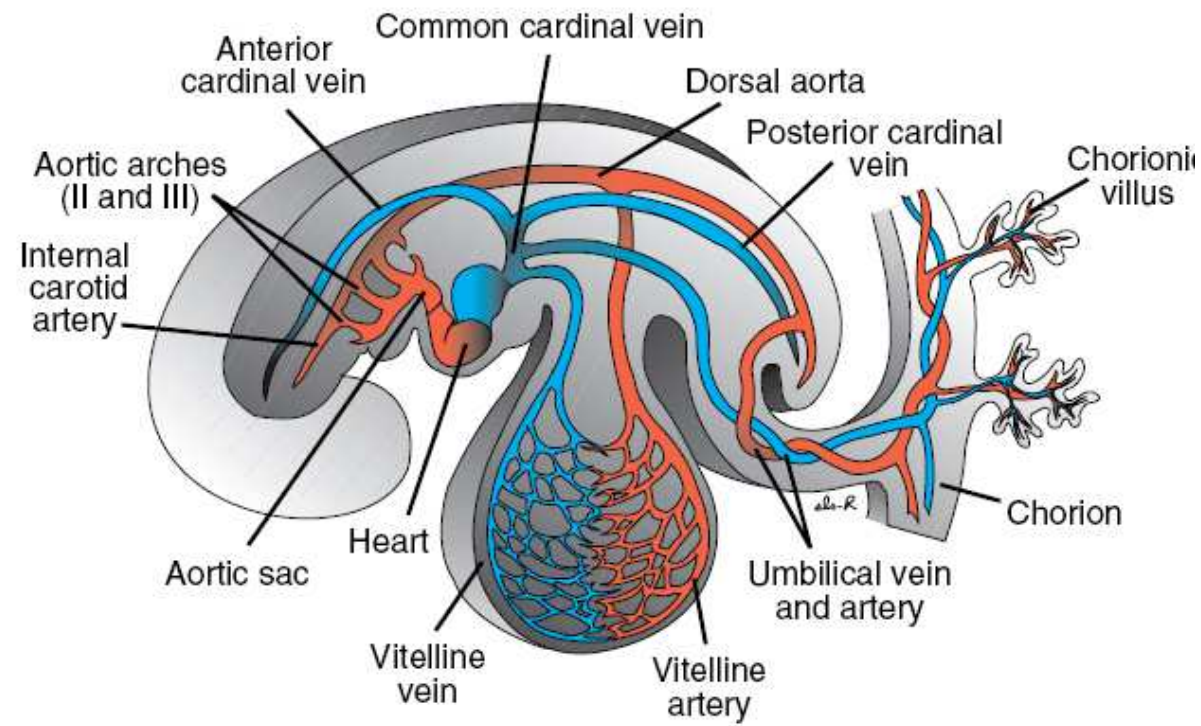
Major vessels (dorsal aorta and cardinal veins) are formed by vasculogenesis while the remainder of vascular system forms by angiogenesis.

Development of arteries:

Occurs as follows:

- The distal part of truncus arteriosus is dilated to form the aortic sac. It is formed of a stem and 2 horns.**
- Two dorsal aortae (rt. & Lt.) appear . Cranially, they are-connected to the truncus arteriosus, but caudally they fuse together forming a single dorsal aorta.**
- Six pairs of arteries (Aortic arches) appear. They connect the aortic sac ventrally with the 2 dorsal aortae dorsally.**





AORTIC ARCHES:

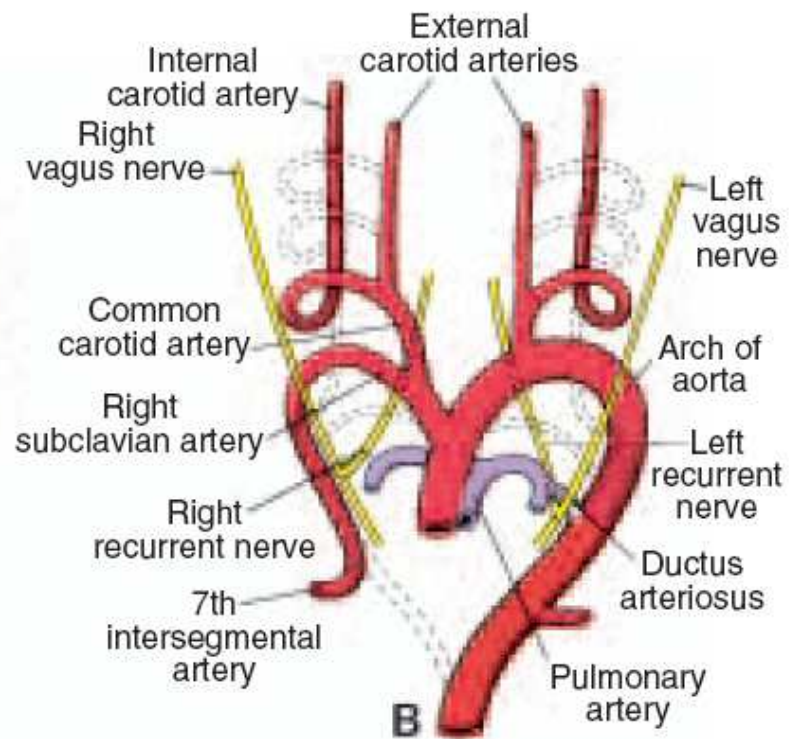
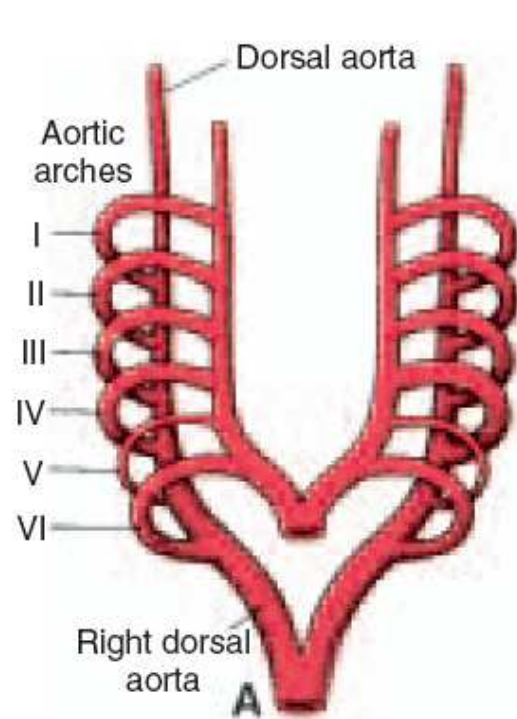
- They are 6 pairs of arteries.**
- Each passes in the corresponding pharyngeal arch and is called the aortic arch artery.**
- They are never present at the same time, as by the time the 3rd pair develops the 1st pair disappears.**

Fate of the aortic arches:

They undergo changes in number and arrangement as follows:

1st : disappears in both sides except for a small part which forms the maxillary artery.

2nd : disappears in both sides except for a small part which forms the stapedial and hyoid arteries.



3rd : forms the common carotid and the proximal part of internal carotid arteries. (the external carotid arises as a bud from the 3rd arch).

4th : - On the Rt. side it forms the proximal part of the rt. Subclavian artery.

- On the Lt. side it forms the middle part of the arch of aorta.

5th : disappears very early and completely on both sides.

6th : each arch divides into ventral and dorsal segments.

- on the rt. Side:

The ventral segment forms the rt. Pulmonary artery.

The dorsal segment disappears.

-On the lt. side:

The ventral segment forms the Lt. pulmonary artery.

The dorsal segment persists during intrauterine life forming the ductus arteriosus connecting the Lt. pulmonary artery to the arch of aorta.

Fate of the aortic sac:

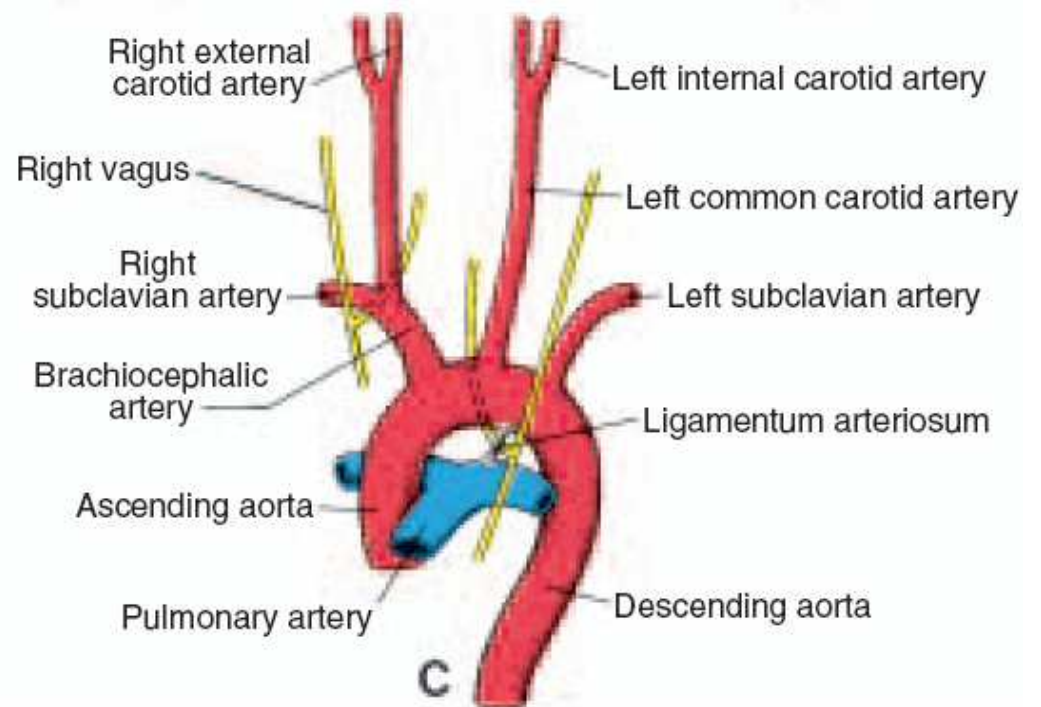
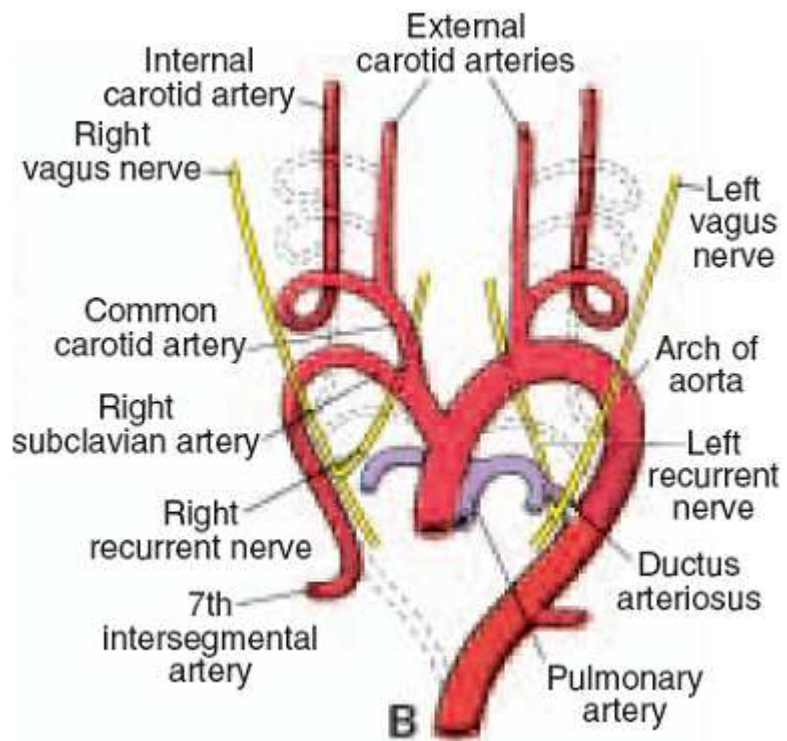
- The Rt. horn form the brachiocephalic artery.**
- The stem and the Lt. horn forms the proximal part of the arch of aorta.**

N.B.

- The recurrent laryngeal nerve is the nerve of the 6th pharyngeal arch.
- Due to caudal migration of the heart, the nerve is pulled down by the 6th aortic arch forming a loop before it returns to the neck.

On the Lt. side: the recurrent laryngeal nerve hooks around the ductus arteriosus.

On the Rt. side: hooks around the rt. subclavian artery in the neck (because the 5th & dorsal part of 6th arches disappear).



Anomalies of arteries:

1- Patent ductus arteriosus (PDA): occur alone or 2ry to coarctation of aorta.

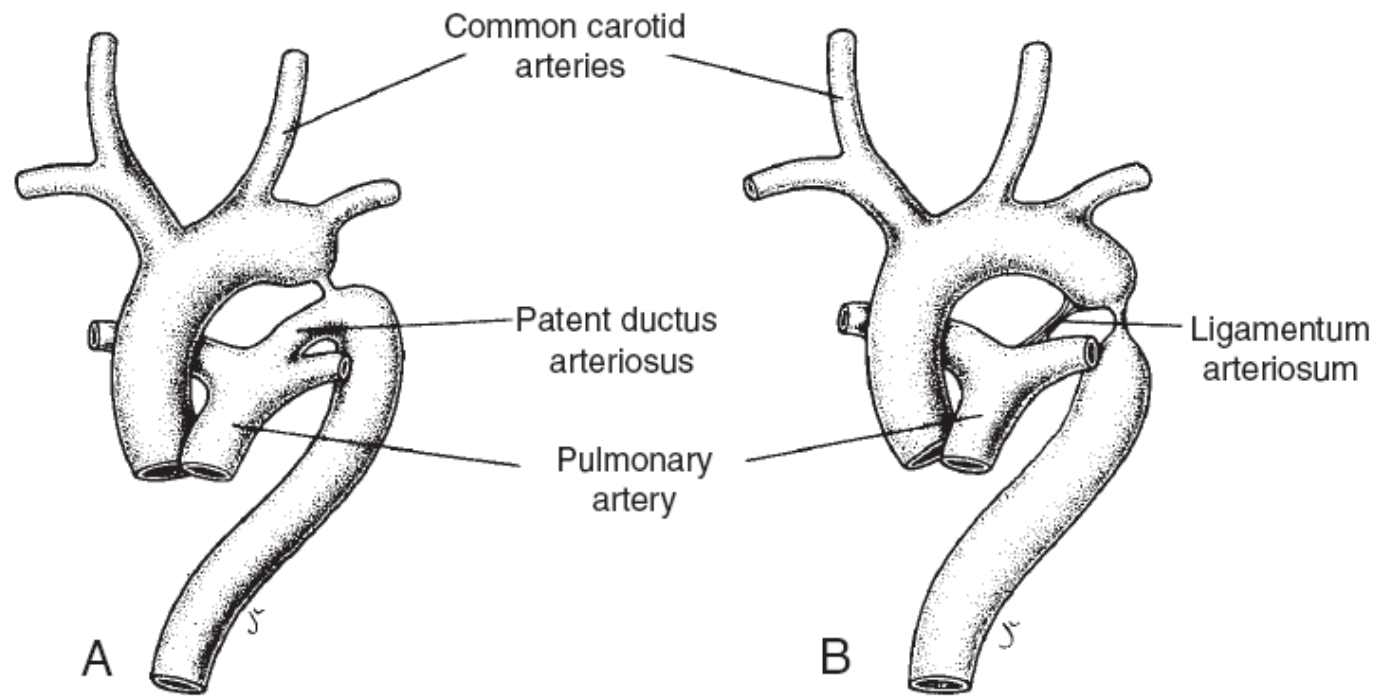
2- Coarctation of aorta: narrowing of a segment of aorta, it may be preductal (PDA) or postductal (no PDA).

3- Anomalies of the arch:

- **Double aortic arch forming a vascular ring around the trachea and oesophagus.**

- **Rt. aortic arch (reversal of the normal).**

- **Interrupted aortic arch**



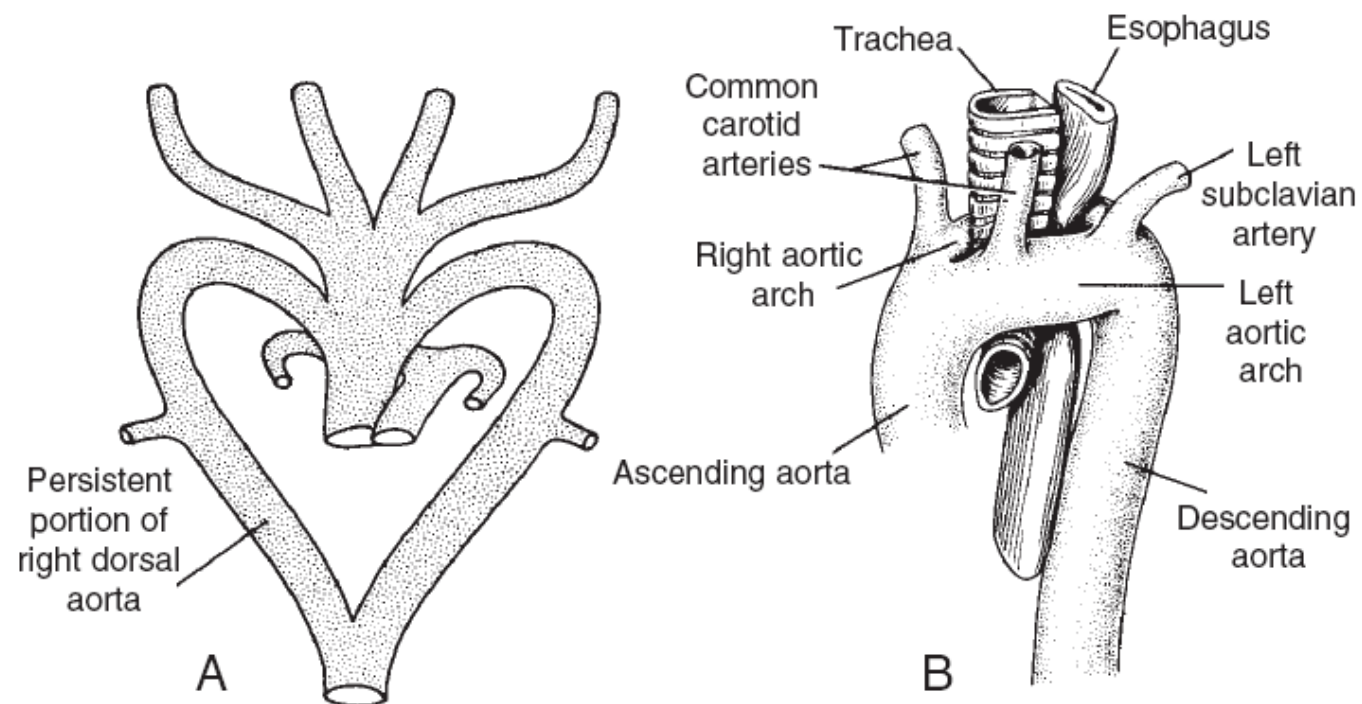


Figure 11.39 Double aortic arch. **A.** Persistence of the distal portion of the right dorsal aorta. **B.** The double aortic arch forms a vascular ring around the trachea and esophagus.

Development of veins:

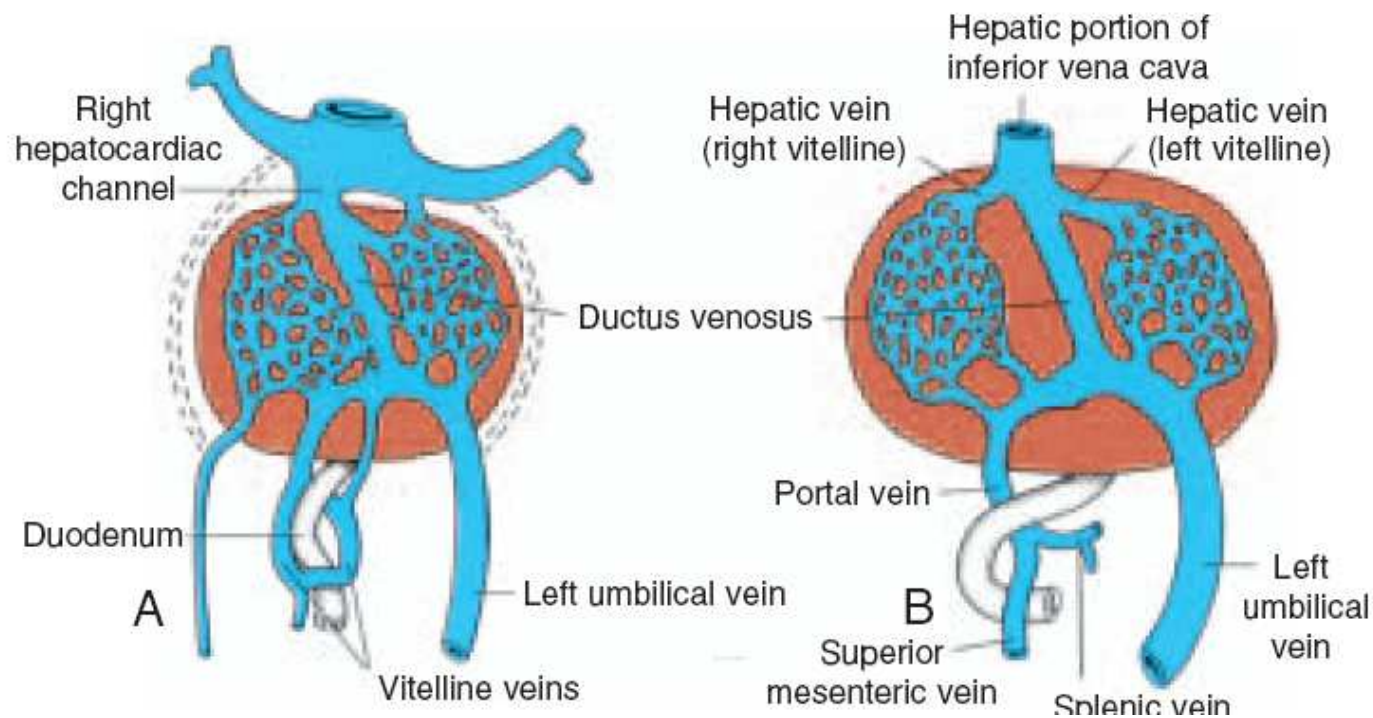
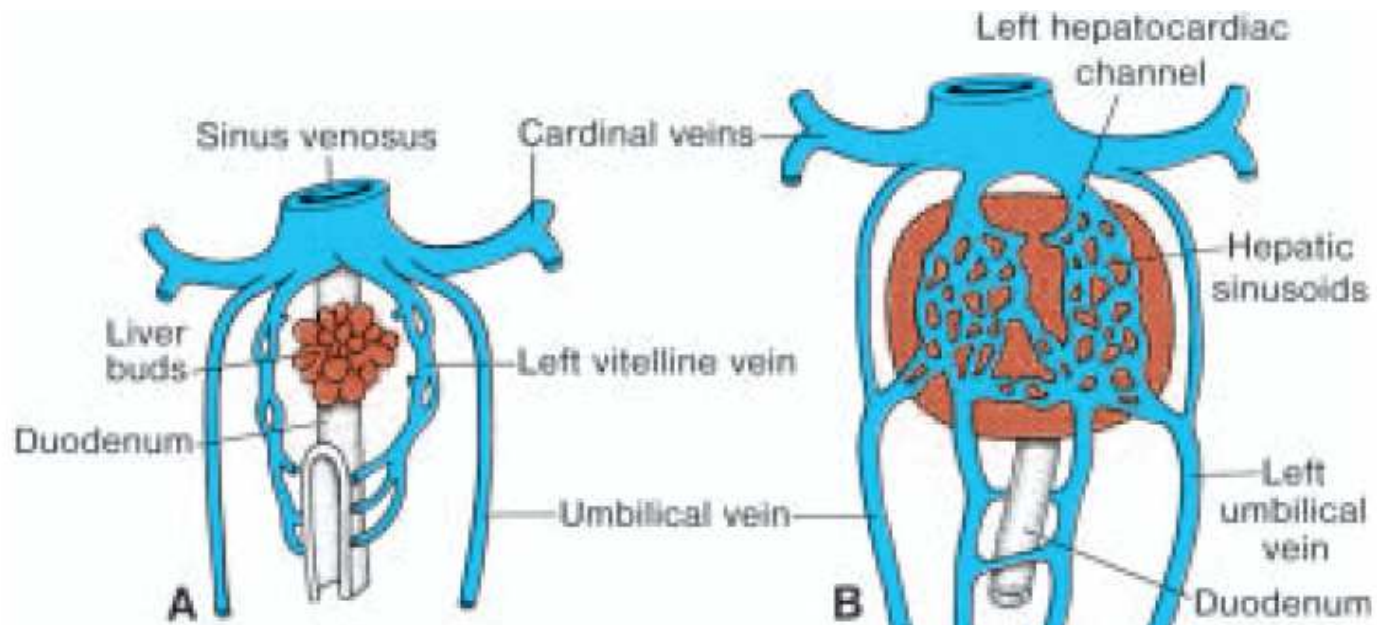
The embryo has 3 pairs of major veins:

1- Vitelline veins:

- They are 2 veins which drain the yolk sac and the gut.
- They pass through the septum transversum to open in the sinus venosus.
- They form the portal system.

2- Umbilical veins:

- They are 2 veins which carry oxygenated blood from the chorionic villi to the sinus venosus after passing through the septum transversum.
- The rt. disappears but the left persists running in the falciform ligament connected to the hepatic vein by a large channel called ductus venosus.



3- Cardinal veins:

- There are 2 common cardinal veins , each is formed by the union of anterior and posterior cardinal veins.
- They drain venous blood from the body wall and end in the sinus venosus.
- They form the caval system.

Anomalies of veins:

- 1- Double SVC.
- 2- Lt. SVC.
- 3- Double IVC.
- 4- Absent IVC.

FOETAL CIRCULATION

- There is no respiration, so the placenta acts as a lung for oxygenation of the foetal blood.

The oxygenated blood is carried from the placenta to the foetus via the Lt. umbilical vein which passes to the liver.

- In the liver, most of the oxygenated blood passes through the ductus venosus to reach the IVC.

- The IVC carries the oxygenated blood (from the placenta) ,which mixes with little amounts of deoxygenated blood reaching the IVC from the lower 1\2 of the body, to the Rt. atrium.

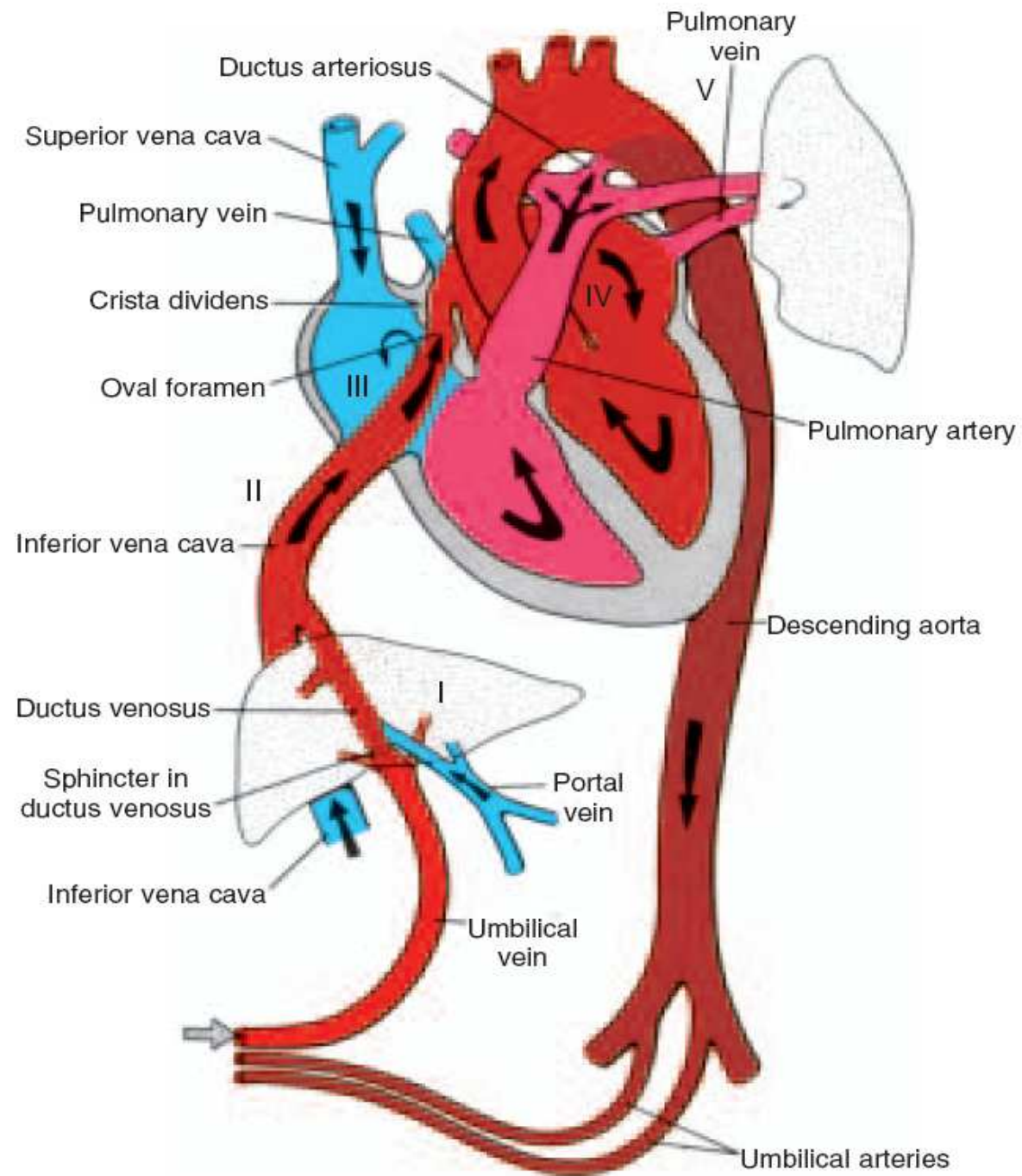
- In the Rt. atrium, most of the blood from the IVC is directed through the foramen ovale to the Lt. atrium.

- From the Lt. atrium, blood passes to the Lt. ventricle and aorta and then distributed mainly to the heart, U.L. & head and neck.

The deoxygenated blood:carried by the SVC reaches the Rt. atrium where it passes directly to the Rt. ventricle then to the pulmonary trunk.

- From the pulmonary trunk, little amount of blood passes to the lung while the majority passes through the ductus arteriosus to reach the distal part of the arch of aorta where it mixes with the oxygenated blood.

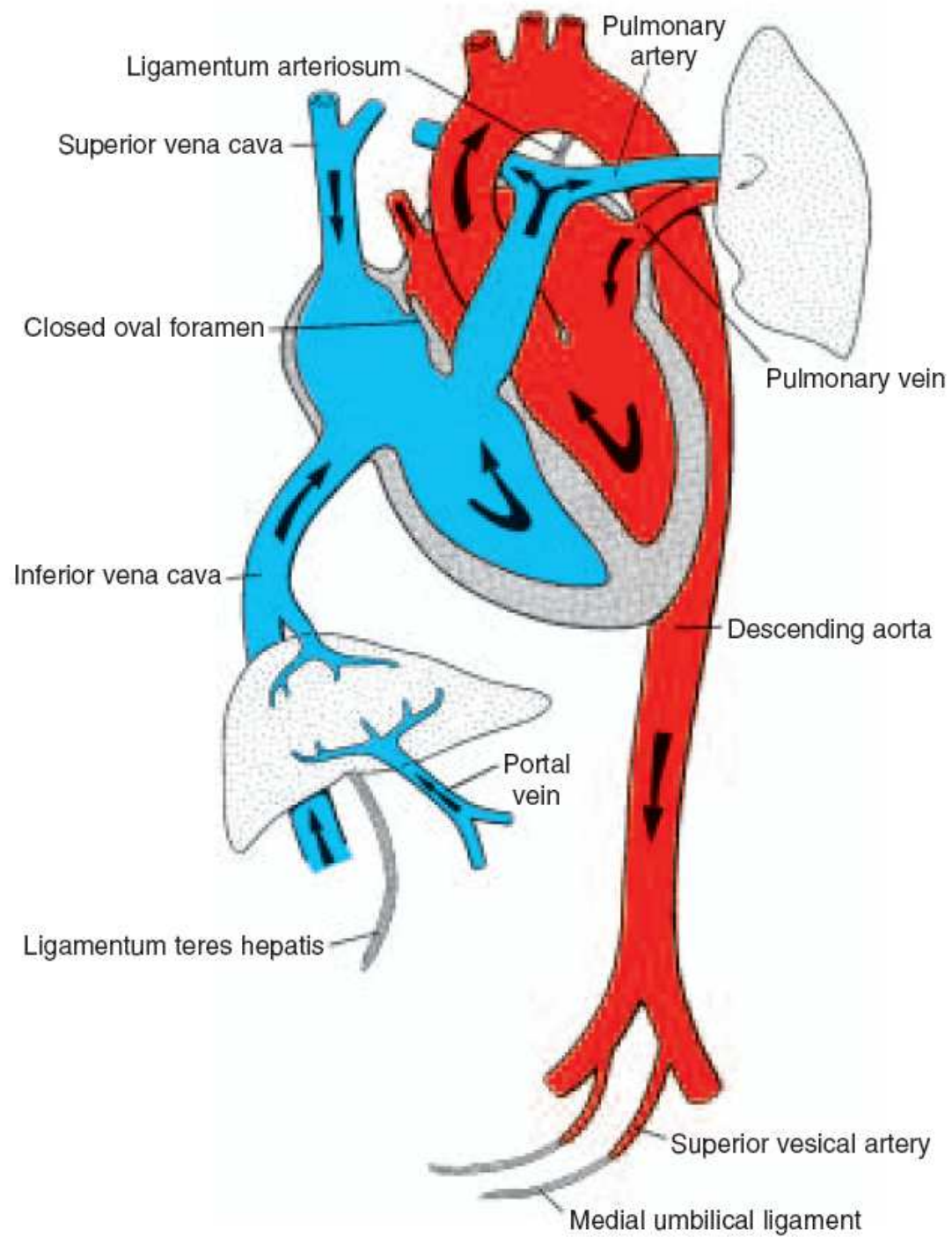
- The dorsal aorta carries partially oxygenated blood which is distributed to the abdomen , lower limbs and finally passes through the 2 umbilical arteries to the placenta to be oxygenated and returned to the embryo again through the umbilical vein.



Changes in the circulation after birth:

Immediate changes:

- Immediately after birth, the lung expands causing negative intra-thoracic pressure leading to suction of blood into the lungs and establishment of pulmonary circulation.
- The increased pressure in the Lt. atrium together with the decreased pressure in the Rt. atrium causes firm apposition of the septum primum to the septum secundum leading to closure of the foramen ovale.
- The ductus arteriosus becomes functionally closed immediately after birth leading to passage of all the blood of the pulmonary artery to the lungs.



Late fibrotic changes:

- During the 1st year of postnatal life some of the vessels become fibrosed and change into ligaments.

1- The Lt. umbilical vein: becomes the ligamentum teres of the liver.

2- The ductus venosus: becomes the ligamentum venosum.

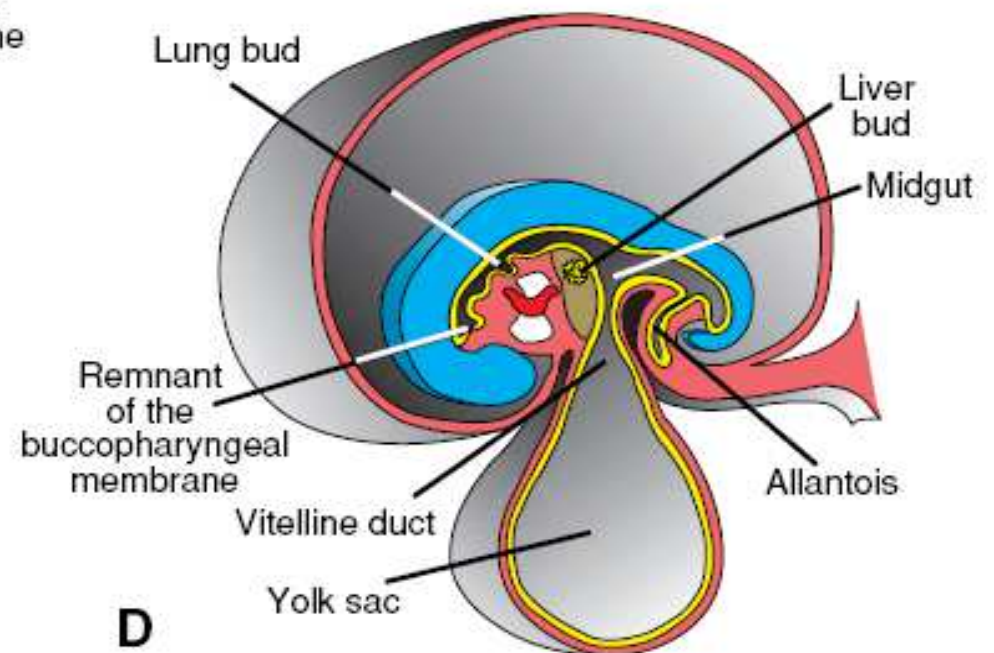
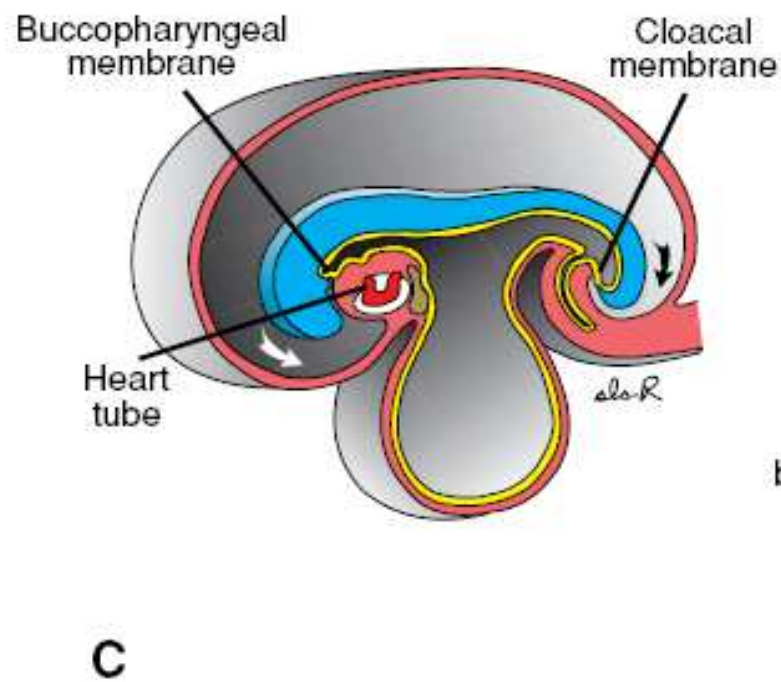
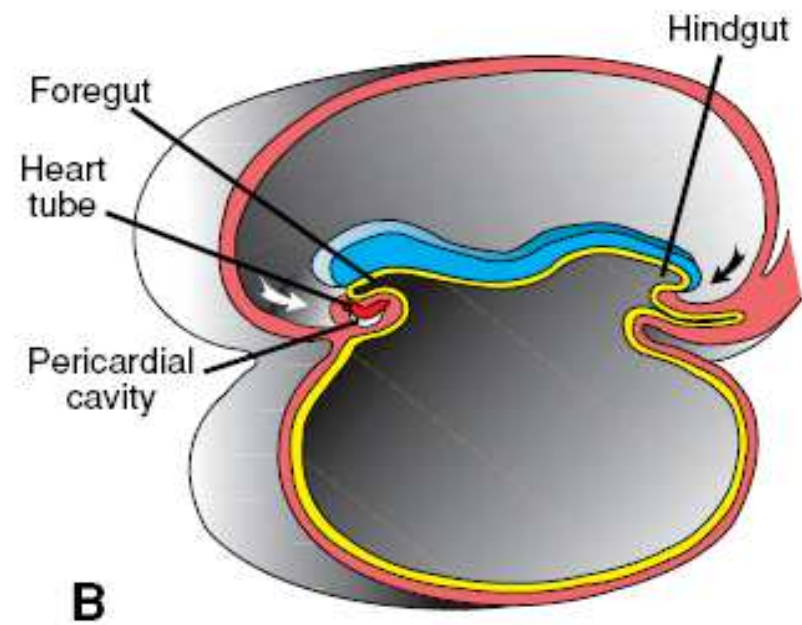
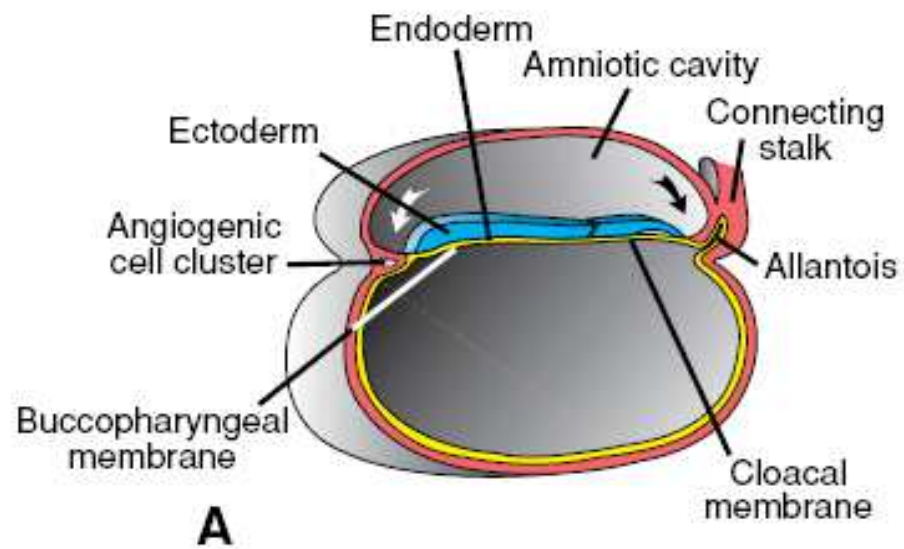
3- Ductus arteriosus: becomes ligamentum arteriosum connecting the Lt. pulmonary artery with arch of aorta.

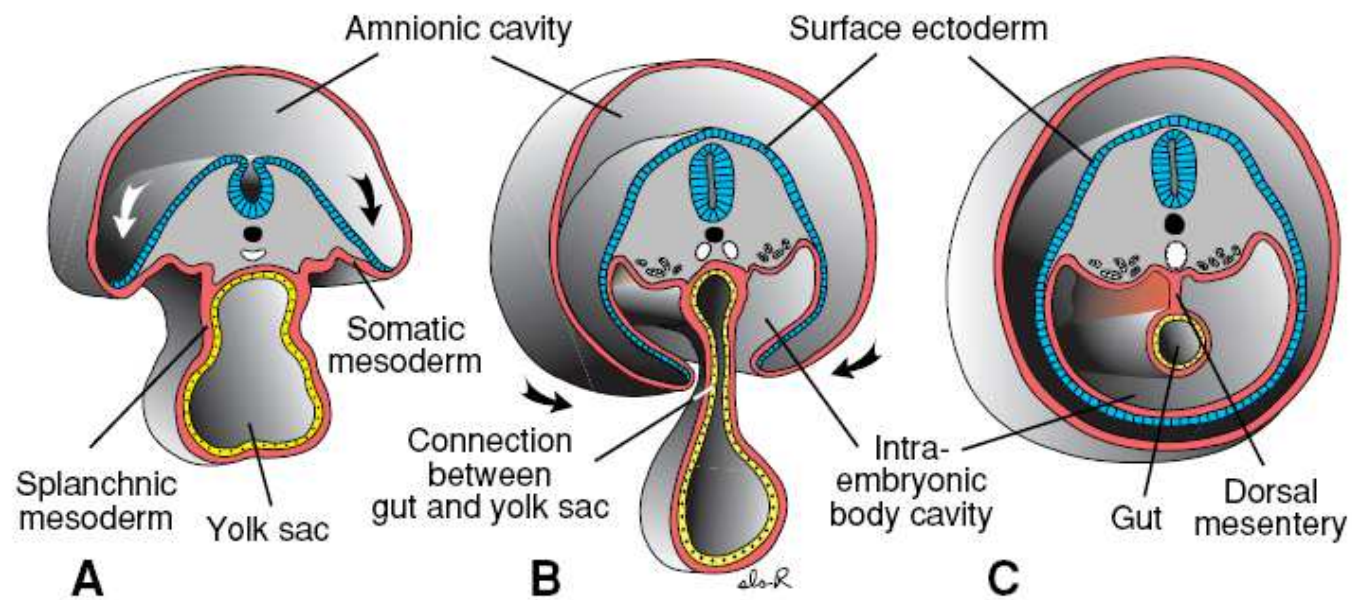
4- The umbilical arteries: become the lateral umbilical ligaments. Their proximal part remains patent gives superior vesical arteries.

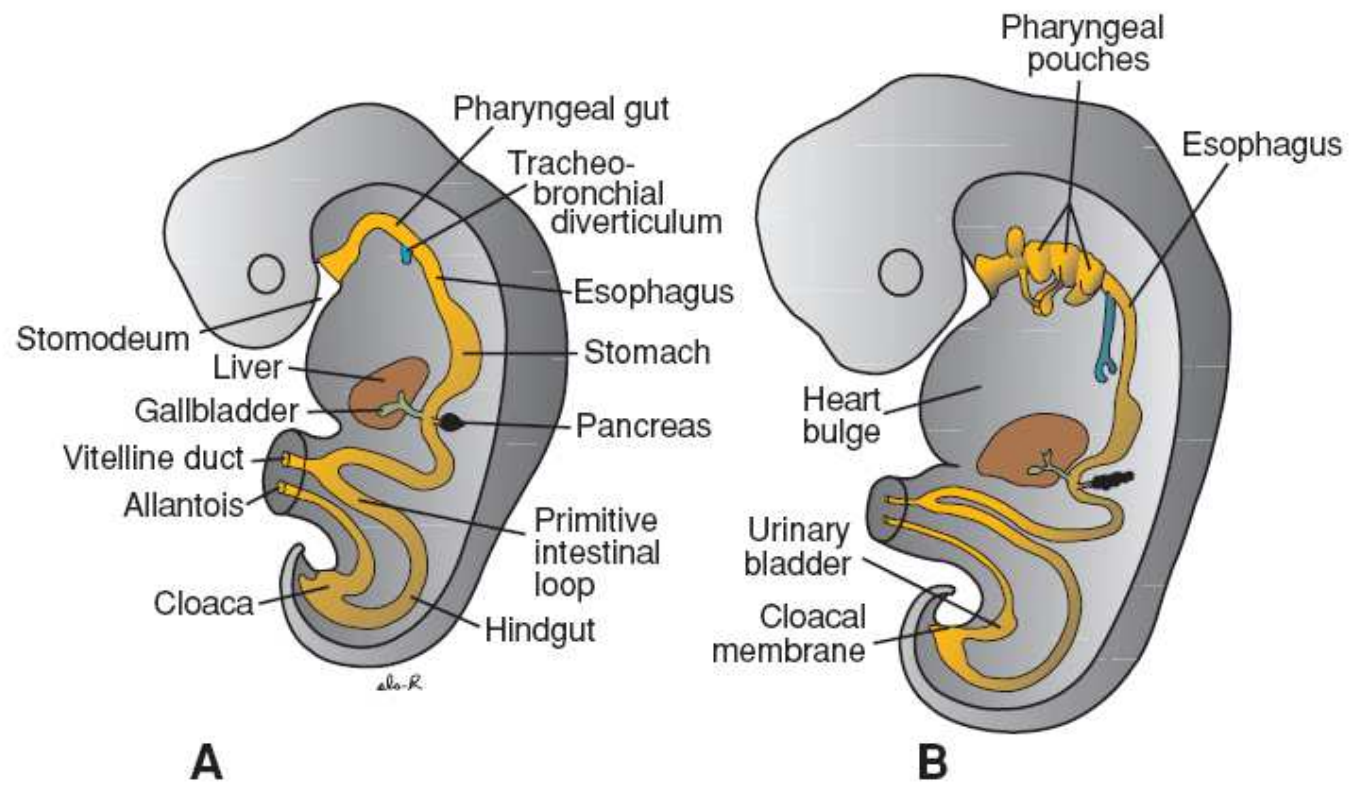
DEVELOPMENT OF THE DIGESTIVE SYSTEM

Early development of the gut tube:

- As the result of folding of the embryo, a part of the endoderm lined yolk sac cavity is enclosed inside the embryo forming the lining of the gut tube.
- 2 parts of the yolk sac remain outside the embryo, the allantois and the yolk sac.
- The gut is discussed in four sections:
 - a- The pharyngeal gut or pharynx: from the bucco-pharyngeal membrane to the tracheobronchial diverticulum
 - b- The foregut: lies caudal to the pharyngeal tube and extends as far as the liver outgrowth.







c- Mid-gut: begins caudal to the liver bud and extends to the junction of the Rt. 2/3 and Lt. 1/3 of transverse colon. It is connected to the definitive yolk sac by the vitello-intestinal duct.

d- Hind-gut: inside the tail fold. Its caudal end is closed by the cloacal membrane..

N.B.

- The endoderm forms:

1- Epithelial lining of the gut.

2- Specific cells (parenchyma) of the glands.

- The splanchnic mesoderm forms:

1- The stroma for the glands.

2- Muscle, connective tissue and peritoneal coverings of the gut.

Derivatives of the fore-gut:

- It gives rise to: the oesophagus, the trachea and lung buds, the stomach and the duodenum proximal to the entrance of the bile duct.
- The liver ,pancreas and the biliary apparatus develop as outgrowths of the endodermal epithelium of the upper part of the duodenum.

Derivatives of the mid-gut:

It gives rise to :the duodenum distal to the entrance of the bile duct and continues to the junction of the Rt. 2/3 and Lt. 1/3 of the transverse colon.

Derivatives of the hind-gut:

- It gives rise to the region from the distal 1/3 of the transverse colon to the upper $\frac{1}{2}$ of the anal canal.
- It also forms parts of the uro-genital system.

MESENTRIES:

- The whole abdominal part of the gut is suspended from the posterior abdominal wall by a double-layered dorsal mesentery. Its parts are named according to the organ connected to it.

- Three arteries, derived from the dorsal aorta, pass between the 2 layers of the mesentery to supply the gut.

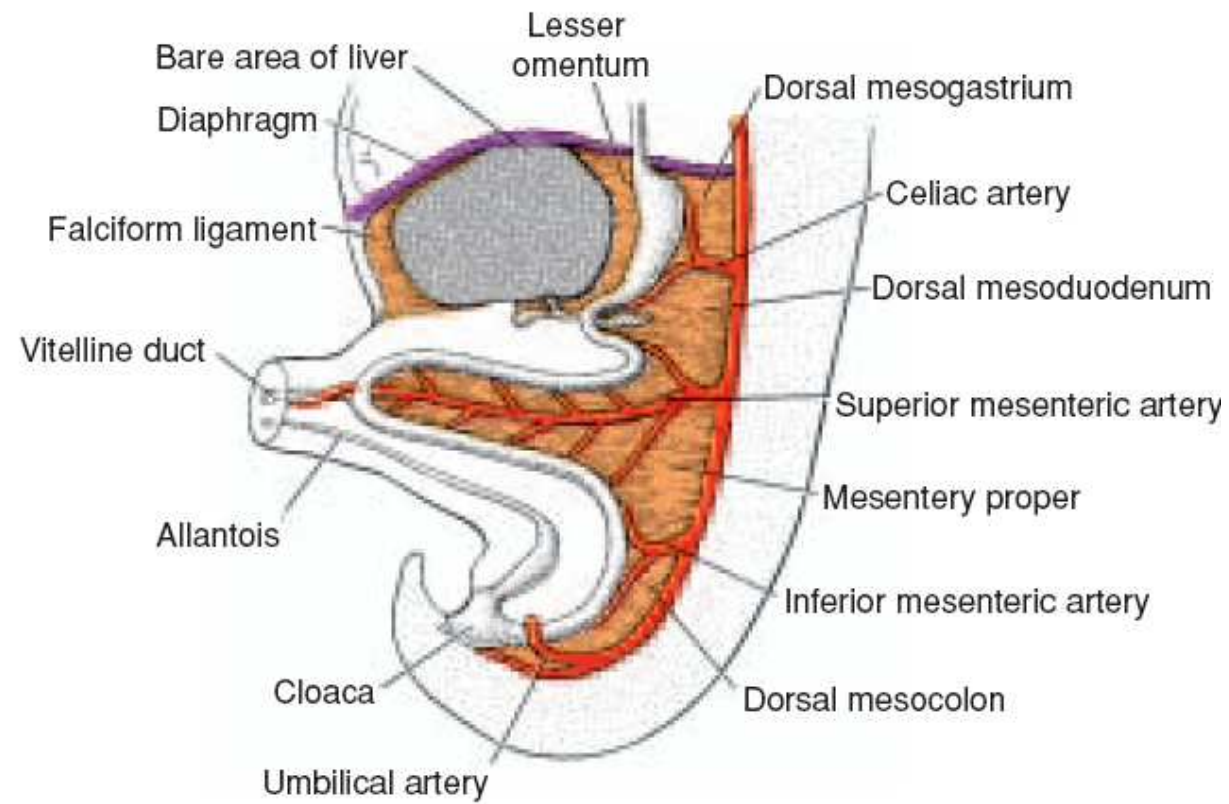
These arteries are:

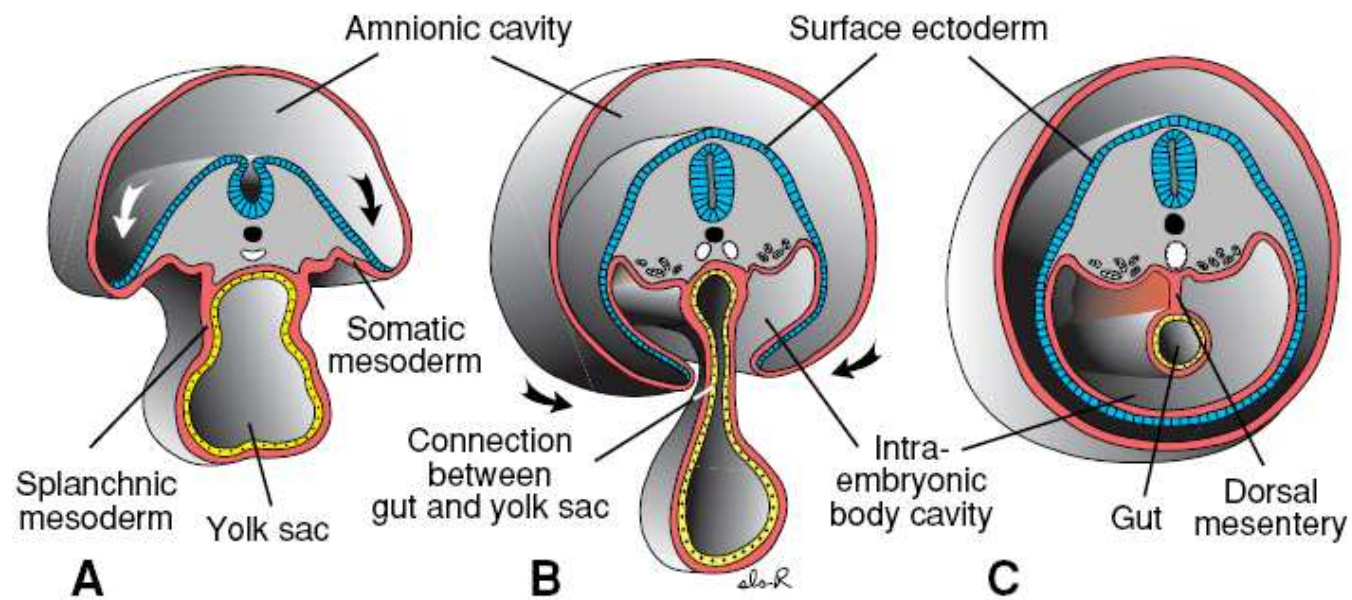
- 1- Coeliac trunk: supplies the fore-gut.

- 2- Superior mesenteric: supplies the mid-gut.

- 3- Inferior mesenteric: supplies the hind-gut.

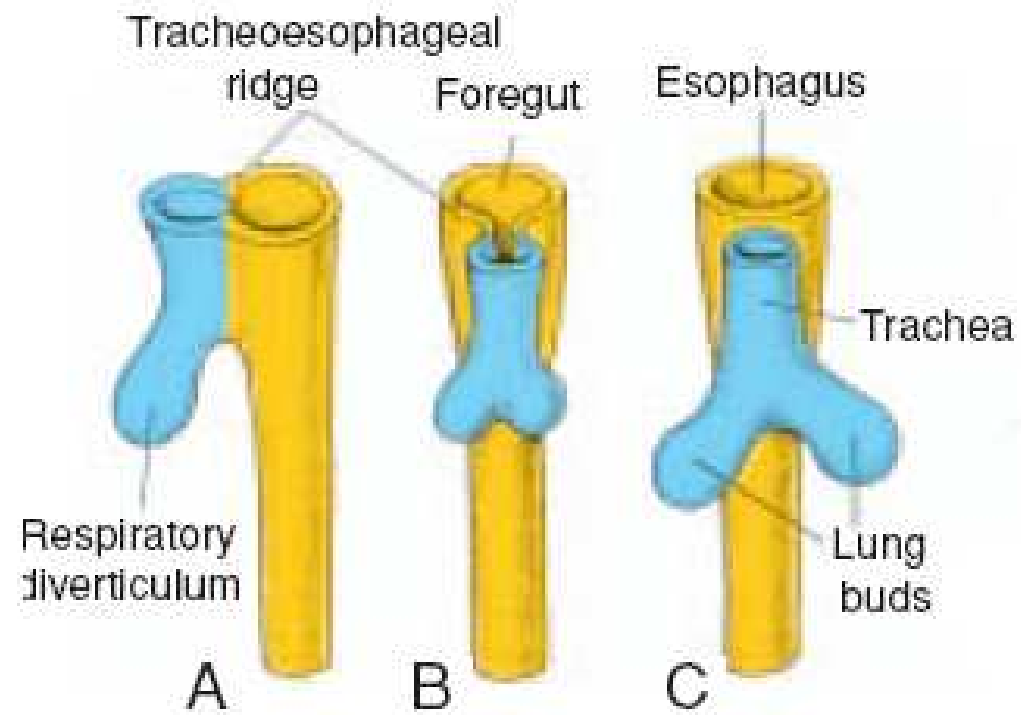
- A ventral mesentery, called ventral mesogastrium (derived from septum transversum) connects the stomach and the cranial most part of the duodenum to the anterior abdominal wall.





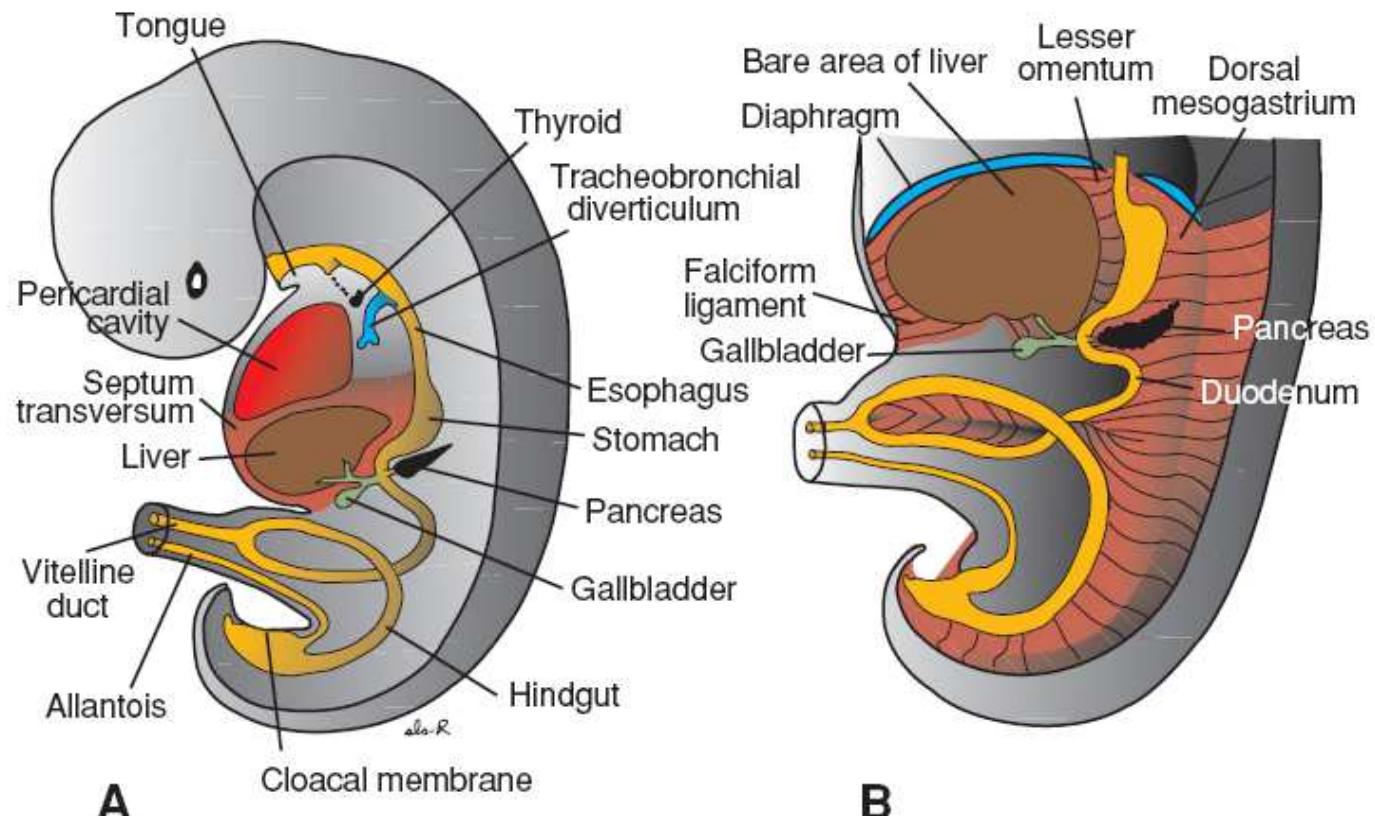
Esophagus:

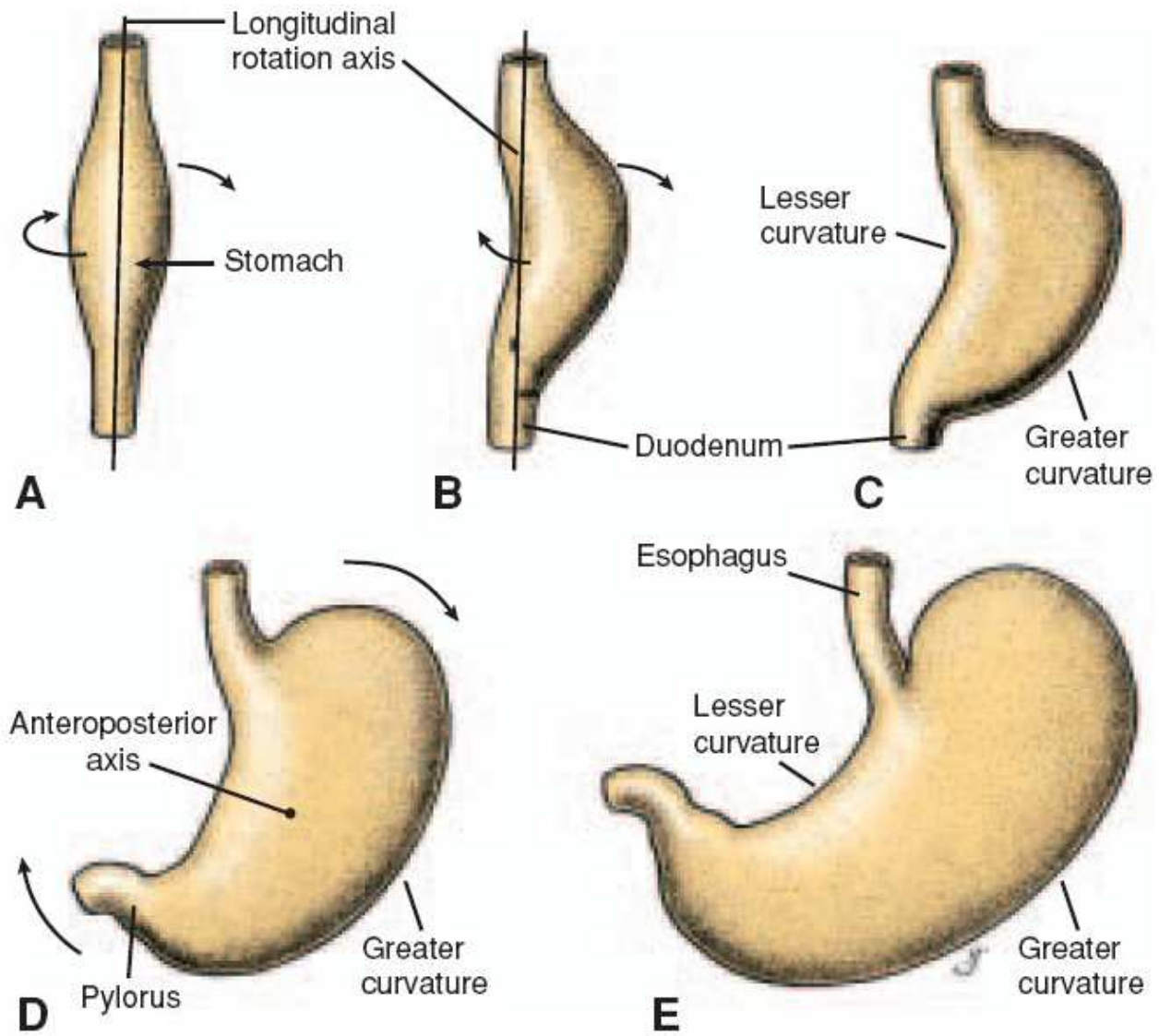
- At the age of 4 weeks, the respiratory diverticulum (lung bud) appears at the ventral wall of the fore-gut distal to the pharyngeal gut.
- The tracheoesophageal septum gradually partitions this diverticulum from the dorsal part of the fore-gut , which is divided into a ventral part (respiratory primordium) and a dorsal part (the esophagus).
- At first the esophagus is short, but with descent of the heart and lungs, it lengthens rapidly.



Stomach

- At the age of 4 weeks, the stomach appears as a fusiform dilatation in the cranial most part of the abdominal fore-gut.**
- At 1st it has:**
 - Two ends :cranial (cardiac) and caudal (pyloric) which lie in the midline.**
 - Two borders: ventral and dorsal (equal in length).**
 - Two surfaces: Rt. and Lt. which are related to the Rt. and Lt. vagi.**
 - Two peritoneal folds: a ventral mesogastrium, connecting the ventral border to the anterior abdominal wall and a dorsal mesogastrium, connecting the dorsal border to the posterior abdominal wall.**





Later changes:

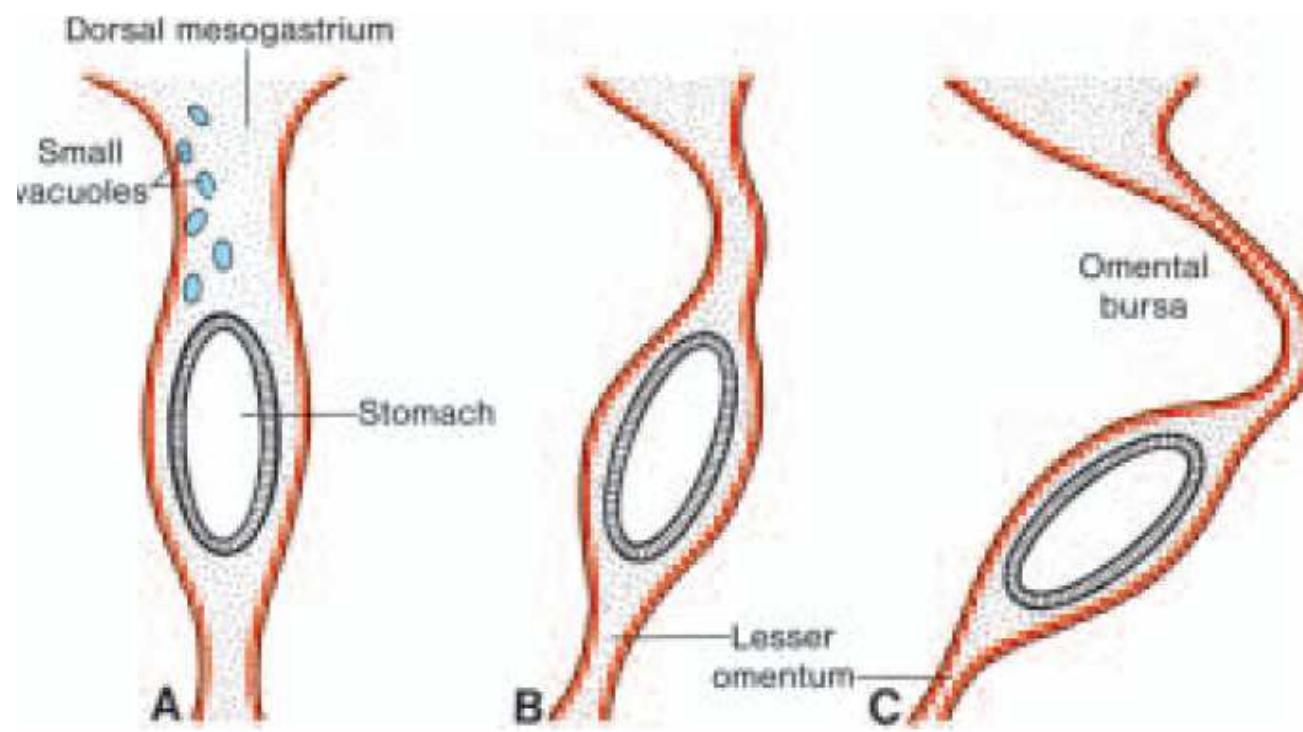
- The dorsal border grows faster than the ventral border forming the greater curvature.

- The stomach rotates 90 degree to the Rt. around its longitudinal axis, this leads to:

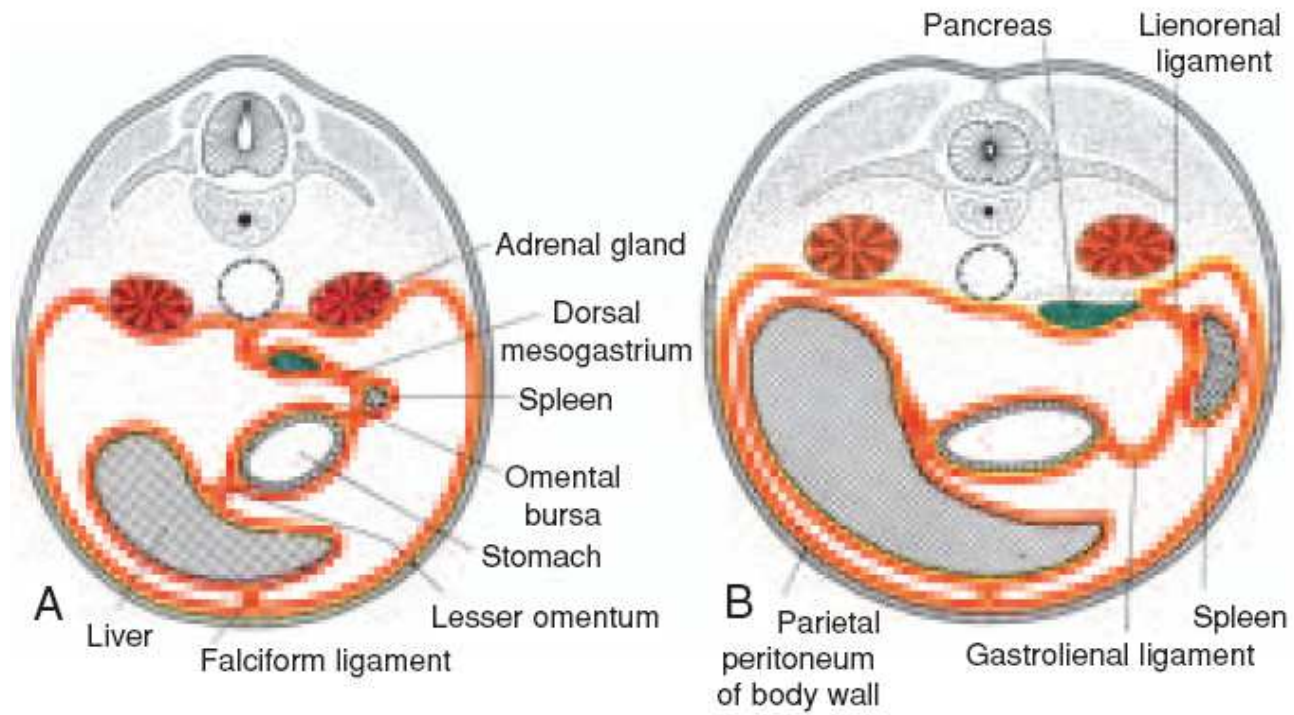
- 1- The Rt. surface becomes posterior & the Lt. becomes anterior and so the Rt. vagus becomes the posterior gastric nerve and the Lt. vagus becomes the anterior gastric nerve.

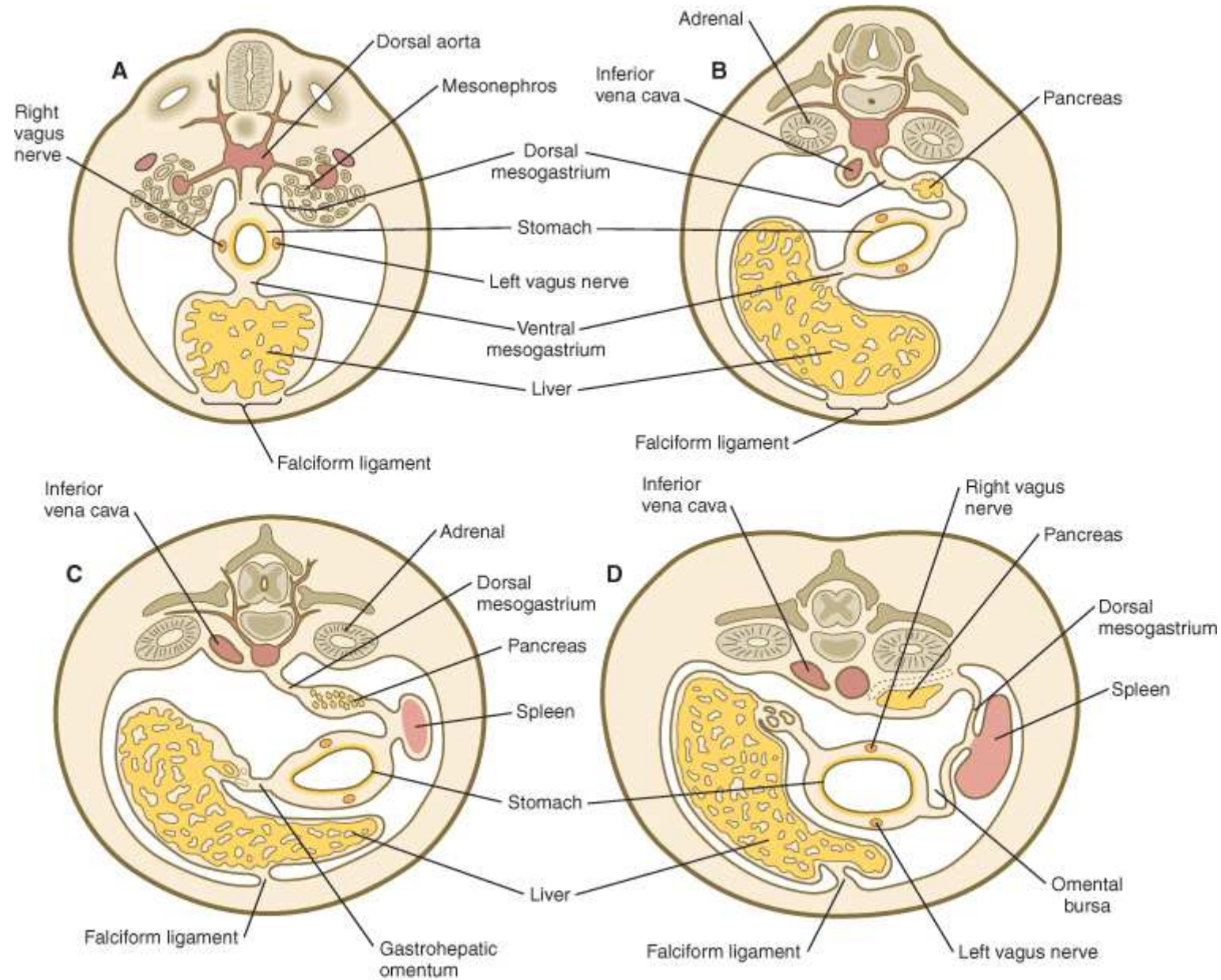
- 2- The lesser curvature faces right & the greater curvature faces left.

- 3- The dorsal mesogastrium becomes stretched and elongated towards the left, thus a peritoneal recess, the lesser sac, is formed behind the stomach.



- The liver develops within the ventral mesogastrium. The part of the mesogastrium between the stomach and the liver forms the lesser omentum and the part between the liver and anterior abdominal wall forms the falciform ligament.
- The enlarging liver pushes the cardiac end to the left.
- The spleen develops from mesodermal cells between the 2 layers of the dorsal mesogastrium. So, the dorsal mesogastrium differentiated into:
 - 1- cranial to the spleen called gastro-phrenic ligament
 - 2- Between the spleen and the stomach the gastro-splenic ligament.
 - 3- Between the spleen and left kidney, lieno-renal ligament.





4- Caudal to the spleen the dorsal mesogastrium continues to grow down and form a double layered sac extending over the transverse colon and intestinal loops forming the greater omentum.

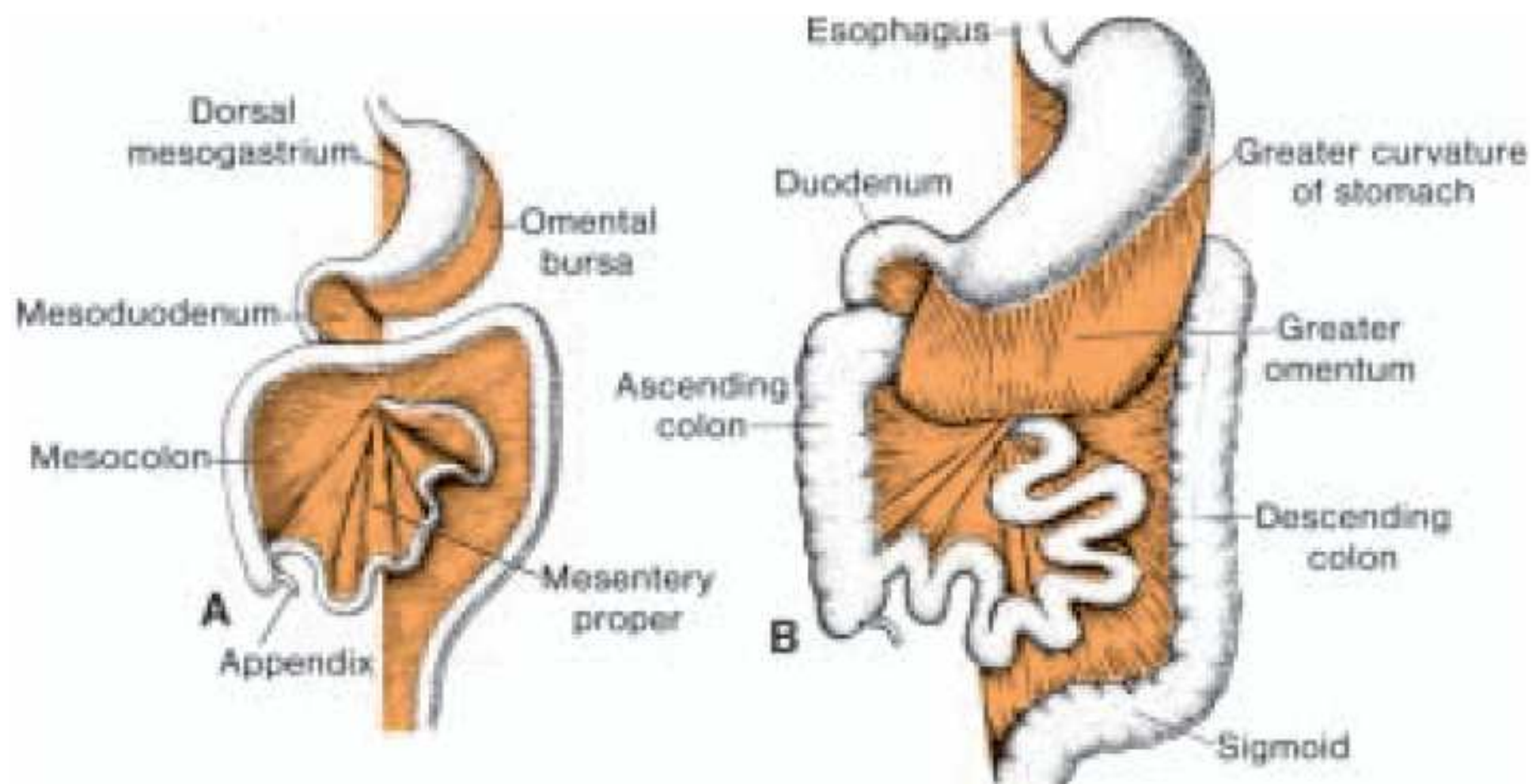
-Later, its layers fused forming a single sheet hanging from the greater curvature of the stomach. The posterior layer of the greater omentum also fuses with the mesentery of the transverse colon.

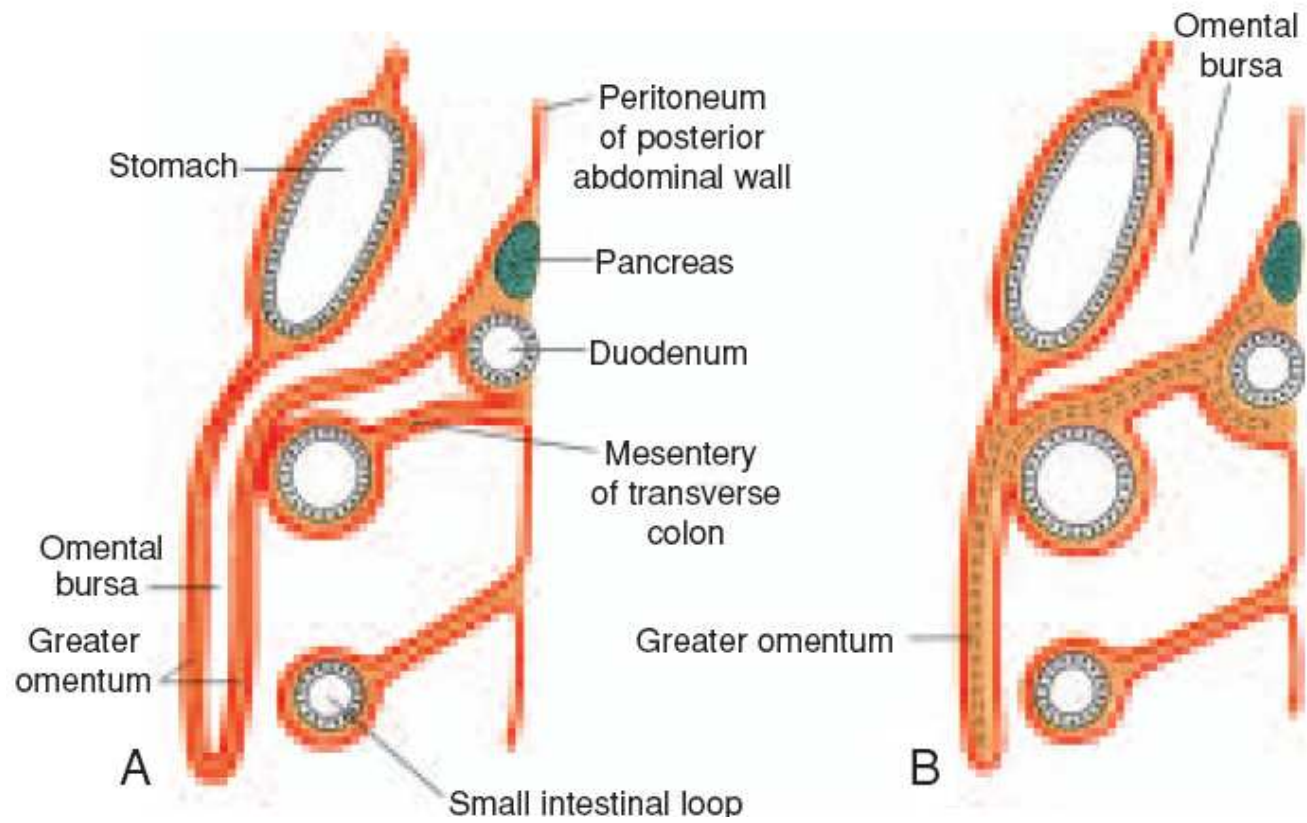
Anomalies:

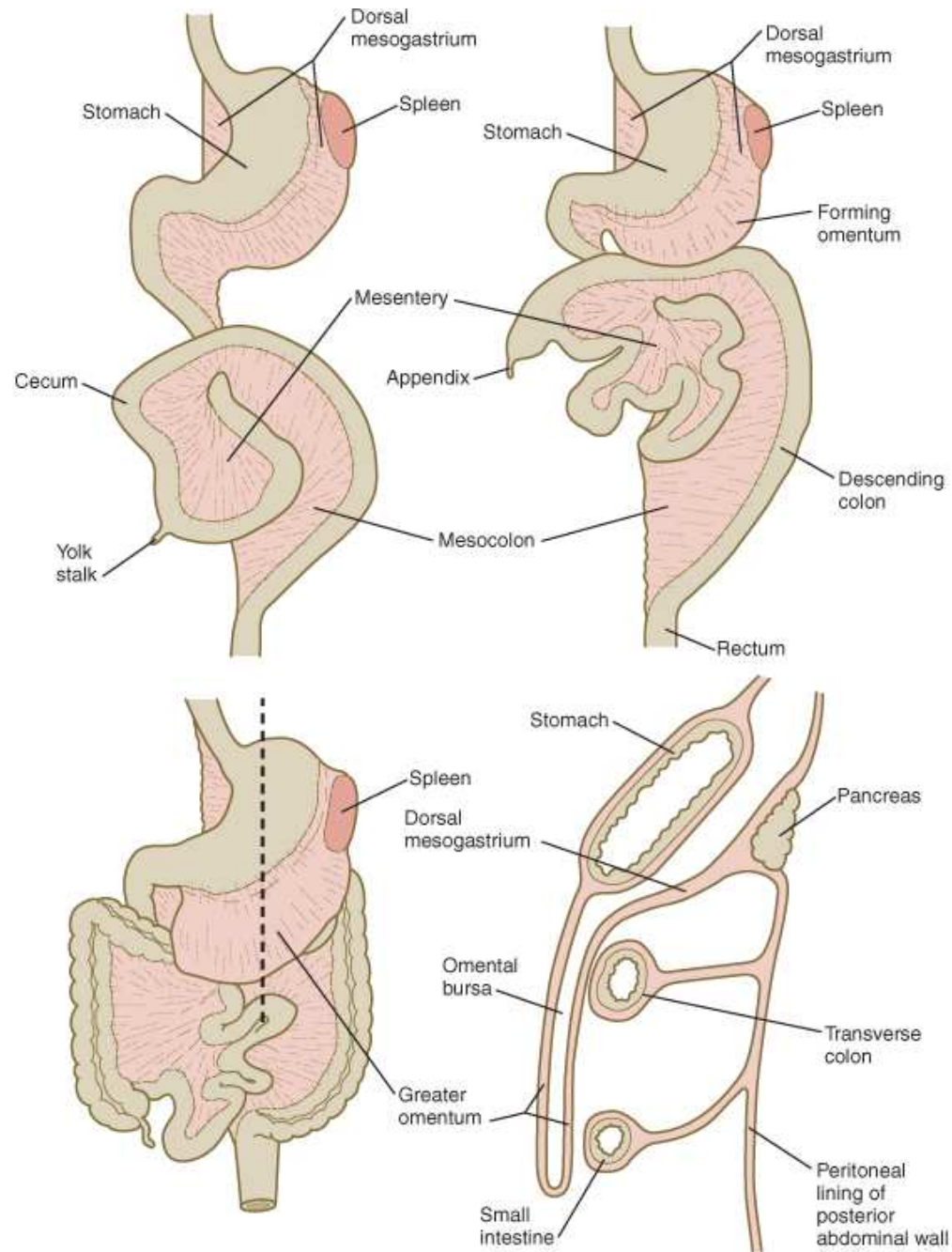
1- Hypertrophic pyloric stenosis: due to hypertrophy of the circular muscle fibers of the pyloric sphincter.

2- Thoracic stomach: due to short esophagus.

3- Hour- glass stomach: constricted middle part.

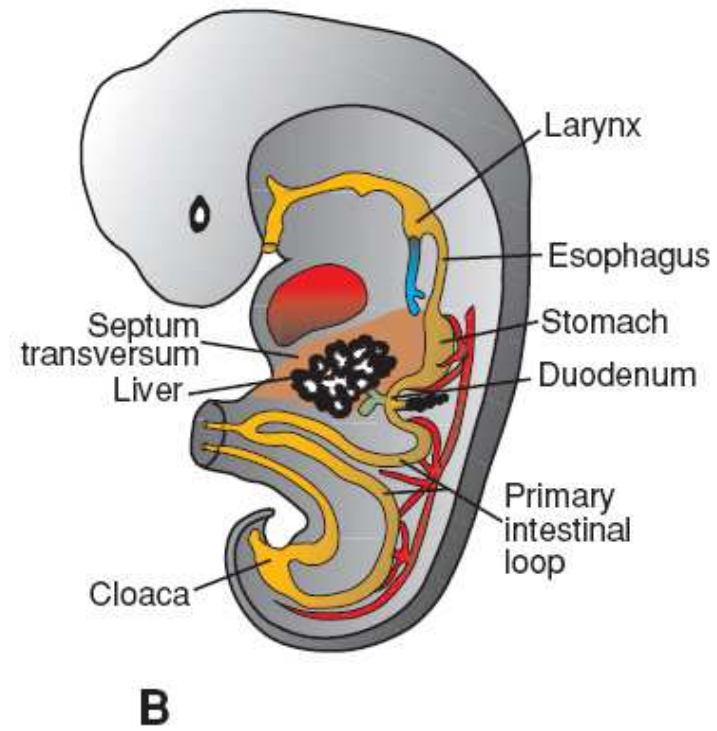
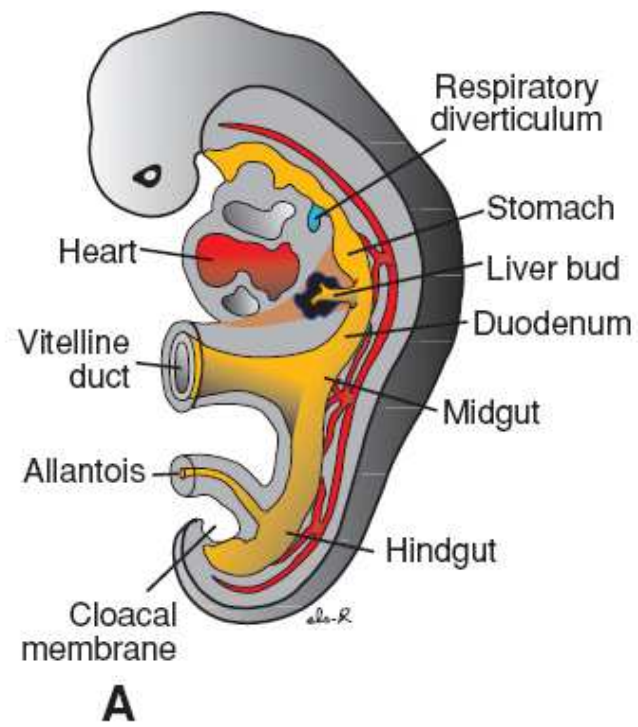


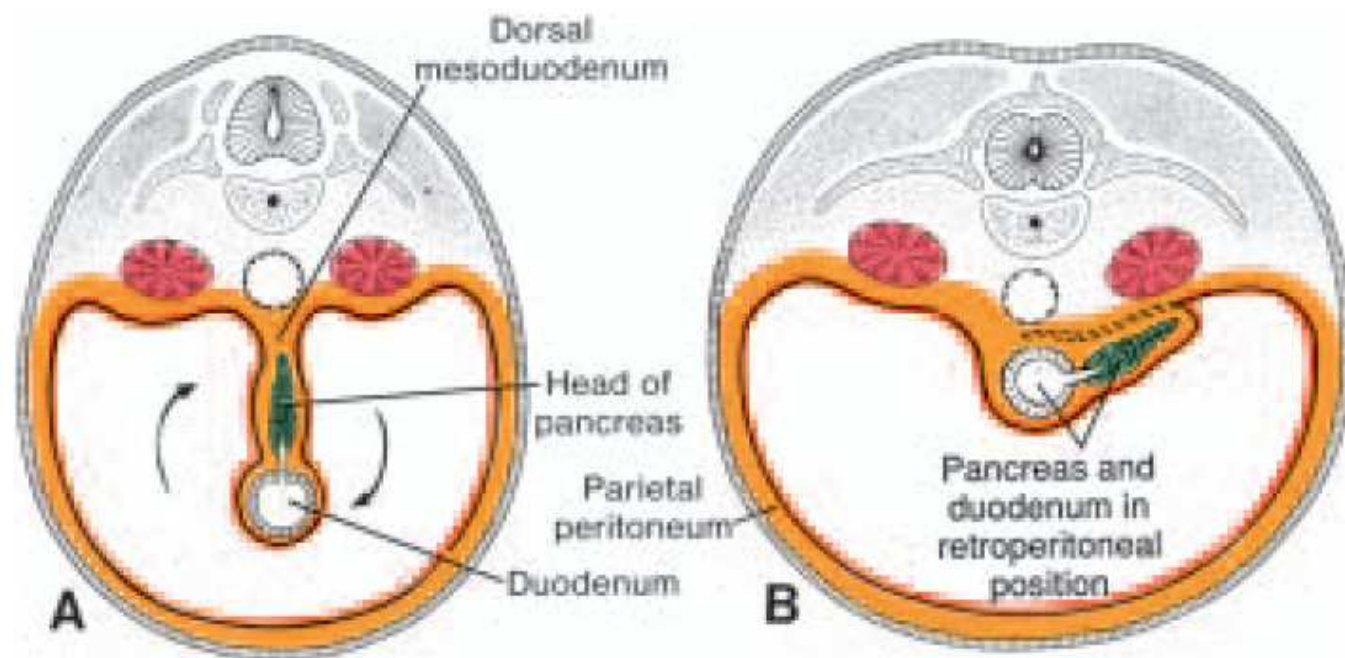




DUODENUM

- It develops from:
 - 1- The caudal part of the fore- gut.
 - 2- The cranial part of the mid- gut.
- The junction between both parts is distal to the origin of liver bud.
- It is in the form of C- shaped loop, with its convexity forward.
- It has a dorsal mesoduodenum, and its 1st inch has ventral mesentry.
- It rotates with the stomach to the Rt. until it rests on the peritoneum of the posterior abdominal wall and fuses with it. The fused peritoneal surfaces become absorbed, thus the duodenum becomes retroperitoneal except 1st inch.

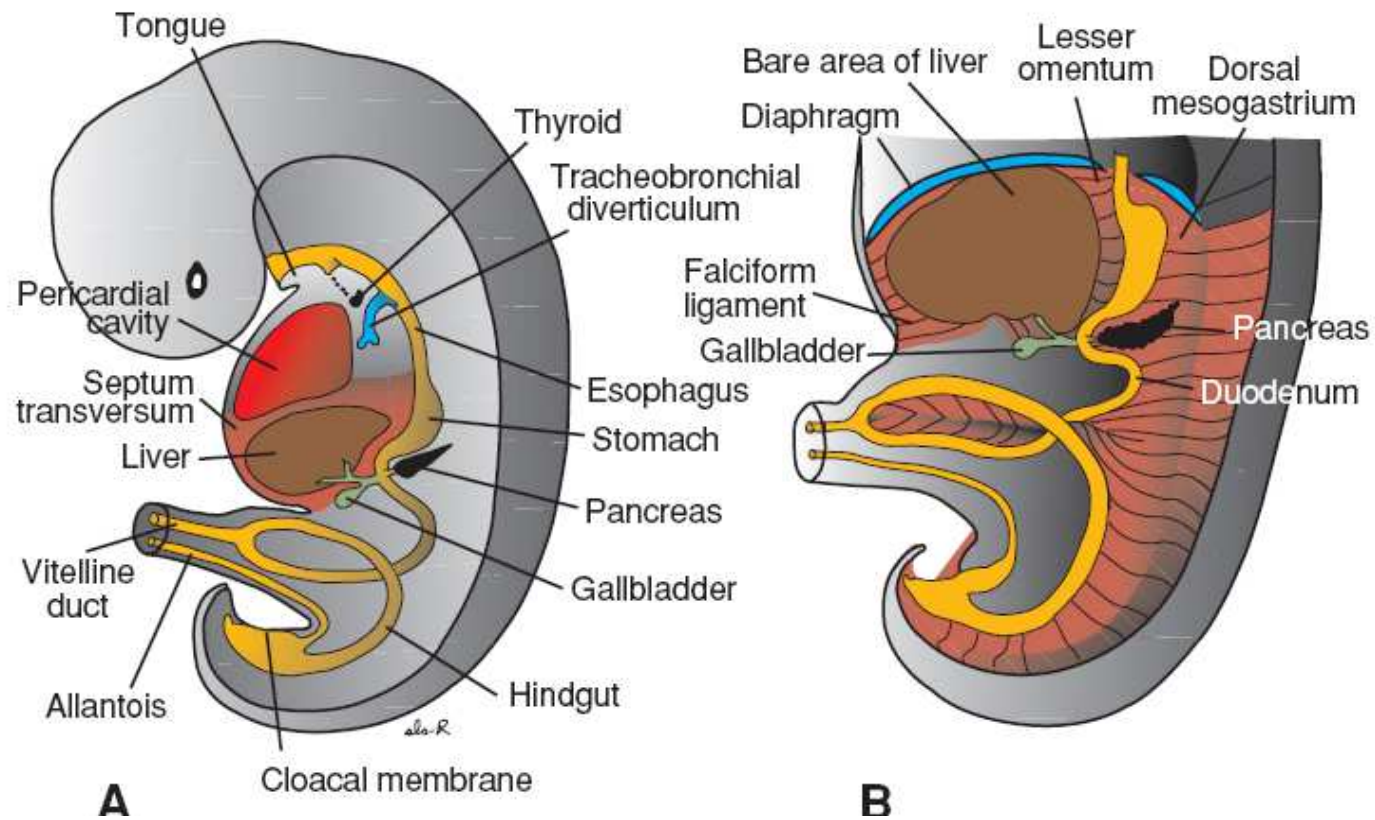


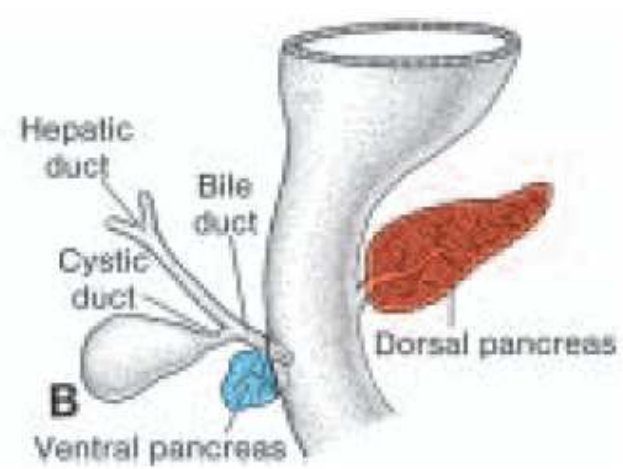
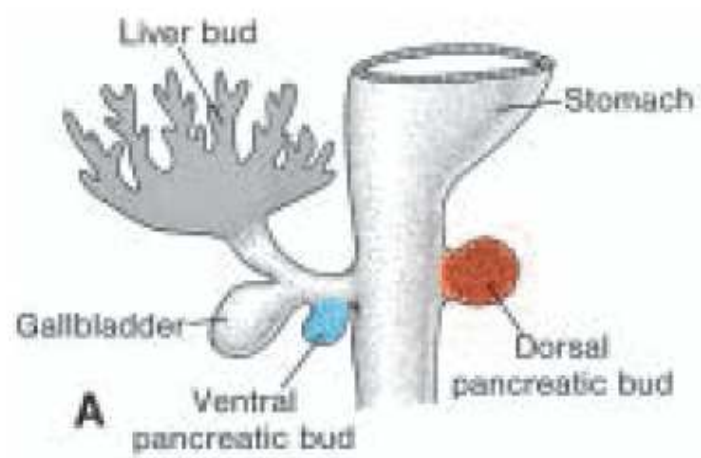


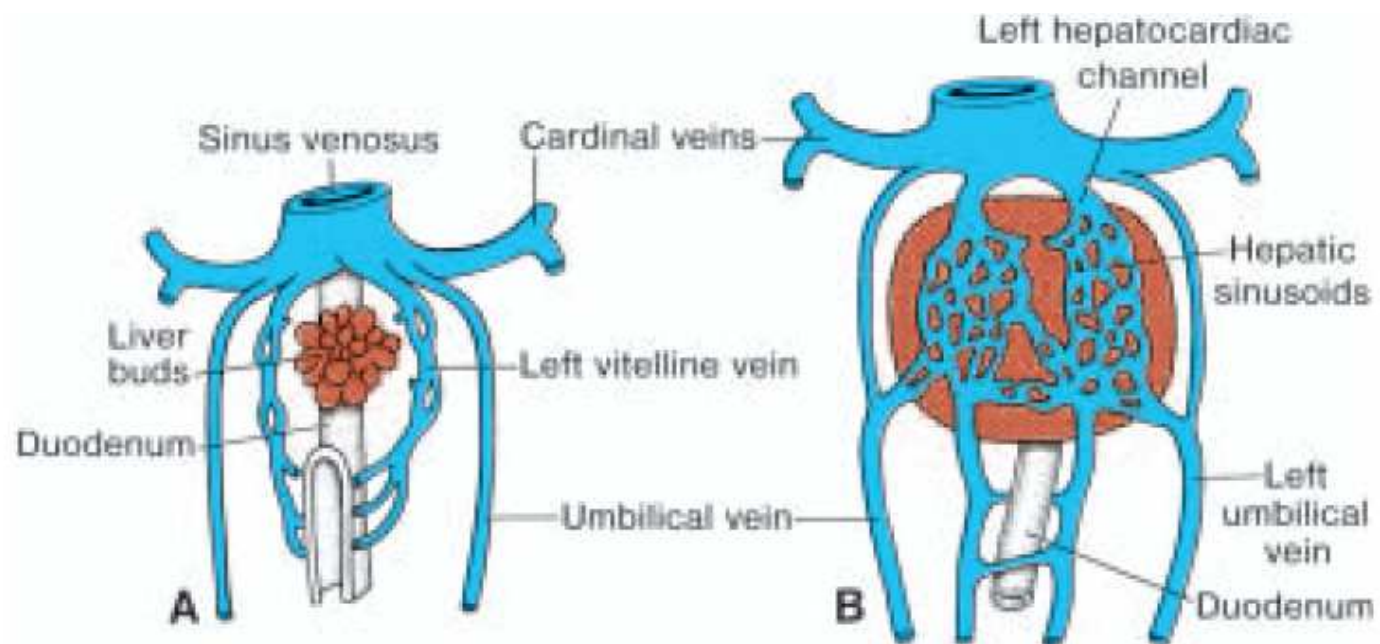
- Due to rotation of the duodenum and unequal growth of its walls, the opening of the liver bud (future common bile duct) is shifted to the posteromedial wall of the duodenum.
- During the 2nd month, the lumen of the duodenum is obliterated by proliferation of its epithelial lining. Then recanalization occurs in the 3rd month.
- Since the duodenum is developed from both the fore- gut and mid- gut so its blood supply is from the coeliac trunk (artery of fore- gut) and superior mesenteric (artery of mid- gut).

LIVER AND GALL BLADDER

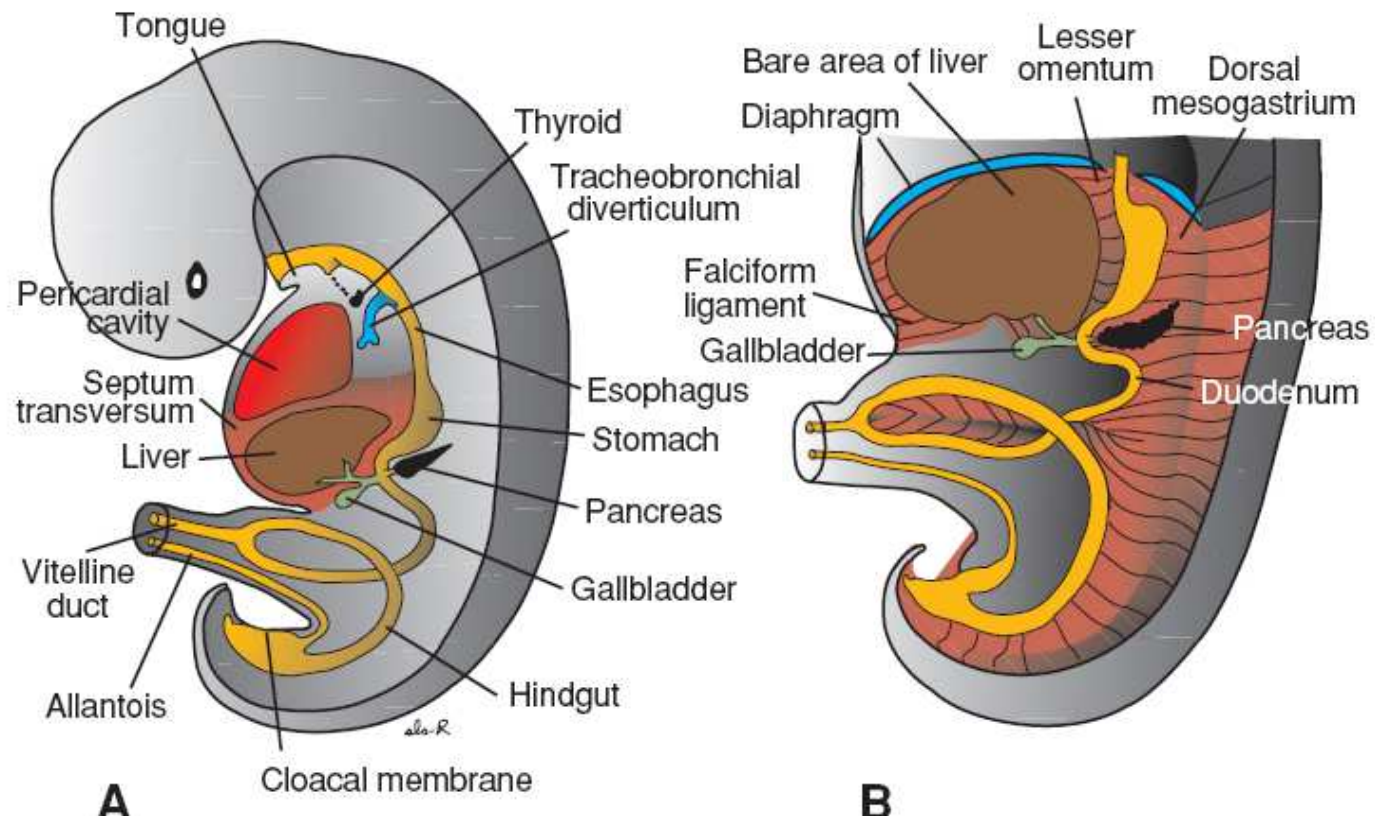
- The liver bud or hepatic diverticulum appears in the middle of the 3rd week as an outgrowth of the endodermal epithelium at the distal end of the fore-gut.
- It consists of rapidly proliferating cells that penetrate the septum transversum.
- The connection between the hepatic diverticulum and the fore-gut narrows forming the bile duct.
- A small ventral outgrowth is formed by the bile duct which gives rise to the gall bladder and cystic duct.
- During further development, the liver cord cells intermingle with the vitelline and umbilical veins which form the liver sinusoids.







- The endodermal liver cords differentiate into the parenchyma (hepatocytes) and form the lining of the biliary passages.**
- The mesoderm of the septum transversum gives rise to hematopoietic cells, Kupffer cells and connective tissue cells.**
- The mesoderm between the liver and the stomach forms the lesser omentum and that between the liver and anterior abdominal wall forms the falciform ligament.**
- During fetal life the liver has 2 functions:**
 - 1- Hematopoietic function: in early intrauterine life and this explains its large size at this stage.**
 - 2- Formation of bile: starts in the 12th week giving green color to the fetal stools.**



PANCREAS

- It develops from :

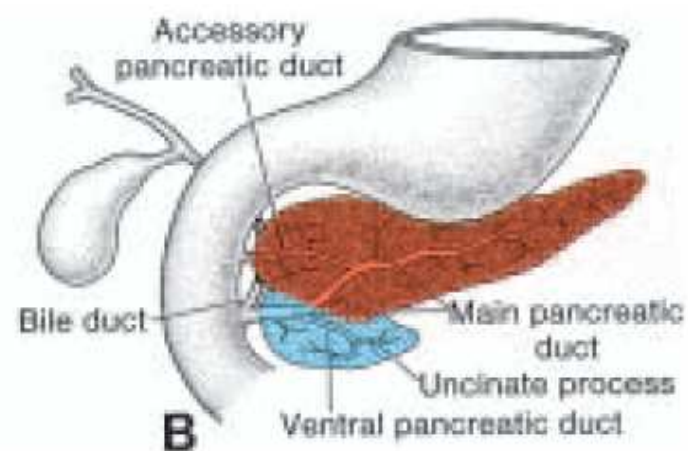
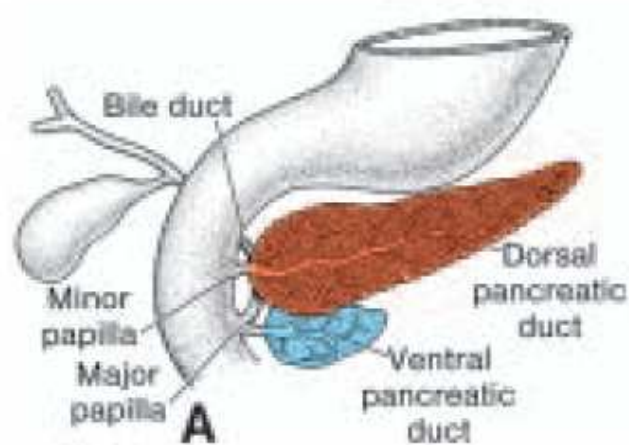
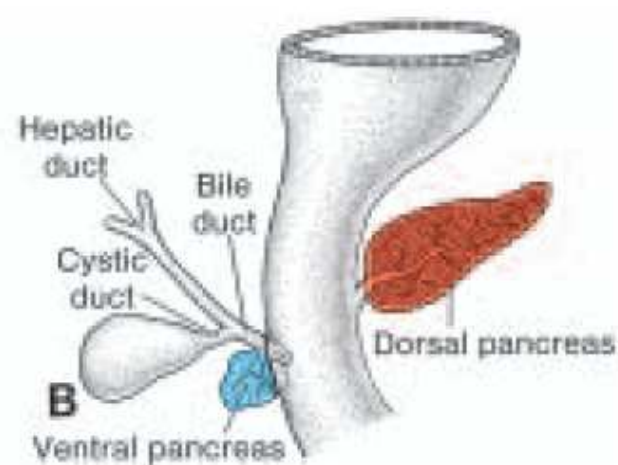
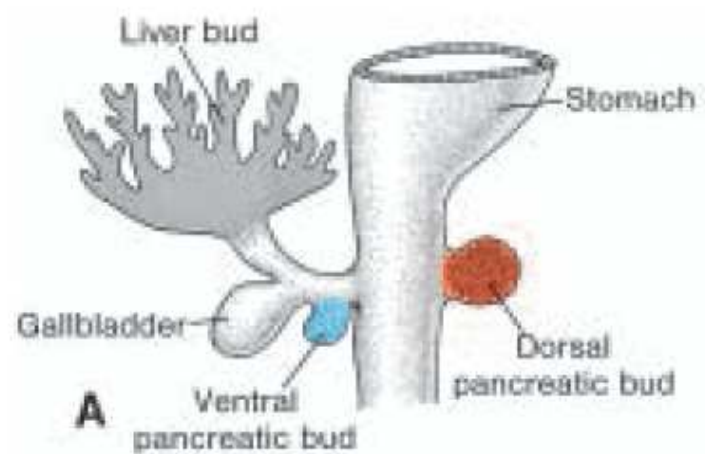
1- Ventral pancreatic bud: from the proximal part of the liver bud.

2- Dorsal pancreatic bud: from the concavity of the duodenal loop cranial to the hepatic bud and lies in the dorsal mesentery..

- The ventral pancreas rotates around the Rt. side of the duodenal loop and comes to lie below and behind the dorsal bud and fuses with it.

- Ventral pancreas forms the inferior part of the head and uncinate process.

Dorsal pancreas forms the rest of the pancreas.



- The main pancreatic duct is formed by the distal part of the dorsal pancreatic duct and the whole ventral pancreatic duct.

The proximal part of the dorsal pancreatic duct either is obliterated or persists to form accessory pancreatic duct.

- The pancreatic acini arise as buds from the ducts.

The islets of Langerhans arise in the 3rd month from the parenchymatous tissue of the pancreas and scattered throughout the pancreas.

Insulin secretion begins at the 5th month.

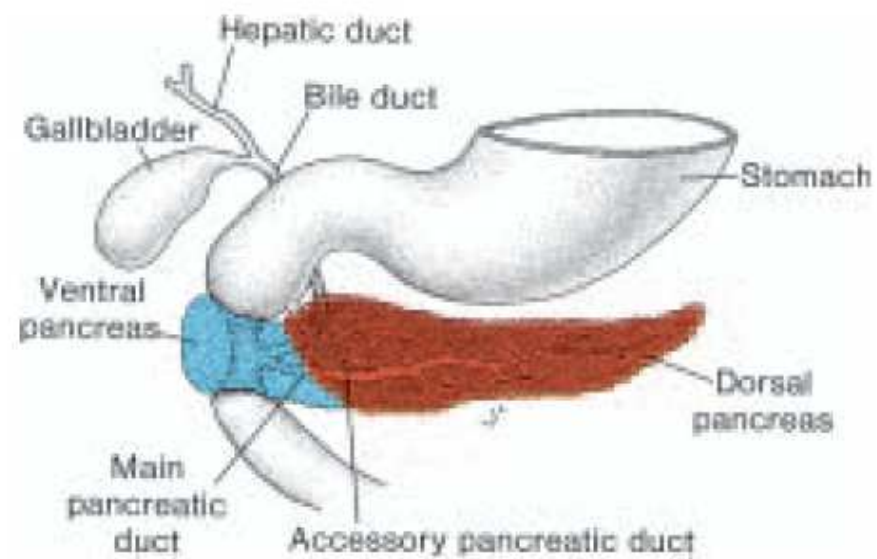
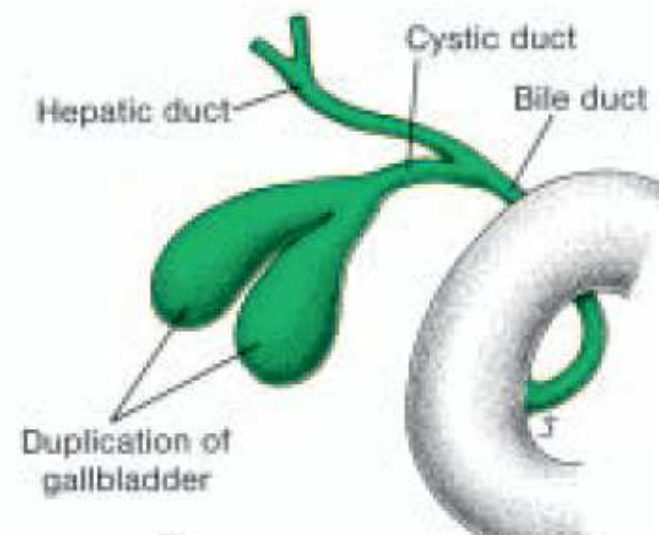
- Splanchnic mesoderm surrounding pancreatic buds forms the pancreatic connective tissue.

Congenital anomalies of the liver and gall bladder:

- 1- Variations in liver lobulation.**
- 2- Accessory hepatic ducts.**
- 3- Duplication of the gall bladder.**
- 4- Extrahepatic biliary atresia.**

Congenital anomalies of the pancreas:

- 1- Annular pancreas: the duodenum is surrounded by pancreatic tissue.**
- 2- Accessory pancreatic tissue: most frequently in the stomach, intestine or Meckel's diverticulum.**



MID-GUT

- **Early appearance:**

- # **At 1st a primary intestinal loop is formed.**

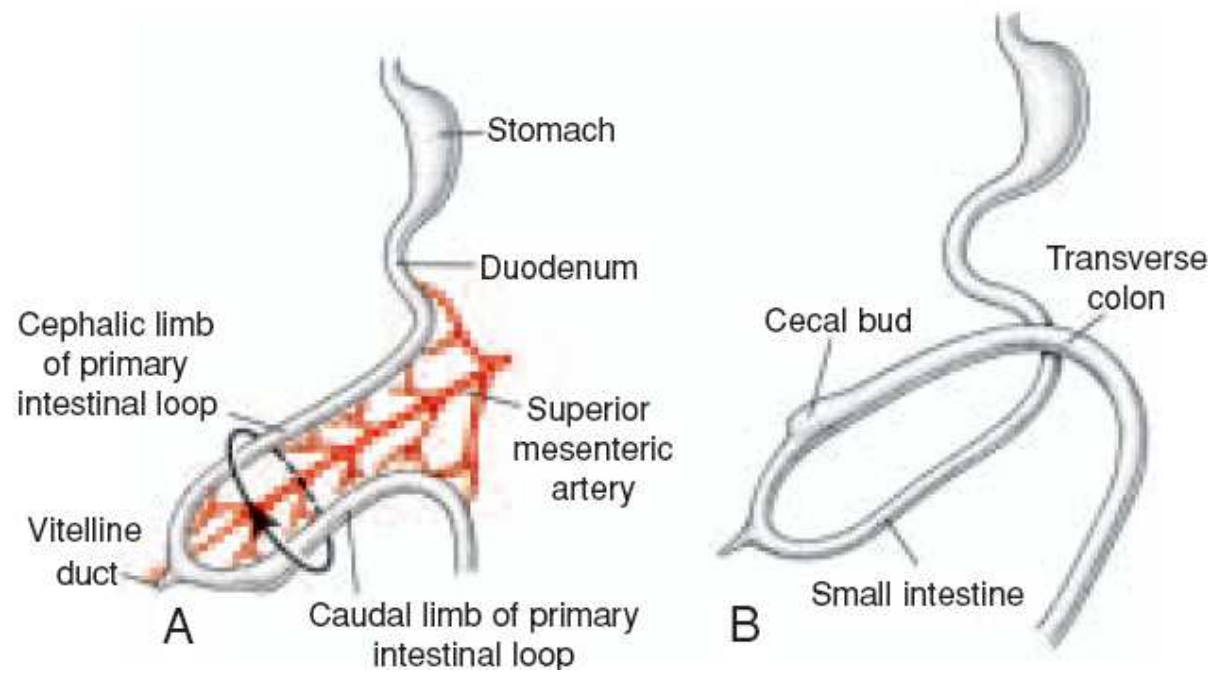
- # **It has 2 limbs, cranial and caudal, and is suspended from the posterior abdominal wall by a dorsal mesentery which contains the superior mesenteric artery.**

- ***The cranial limb develops into the distal part of the duodenum, the jejunum and part of the ileum.**

- ***The caudal limb develops into the lower part of the ileum, the caecum, the appendix, the ascending colon and the proximal 2/3 of transverse colon.**

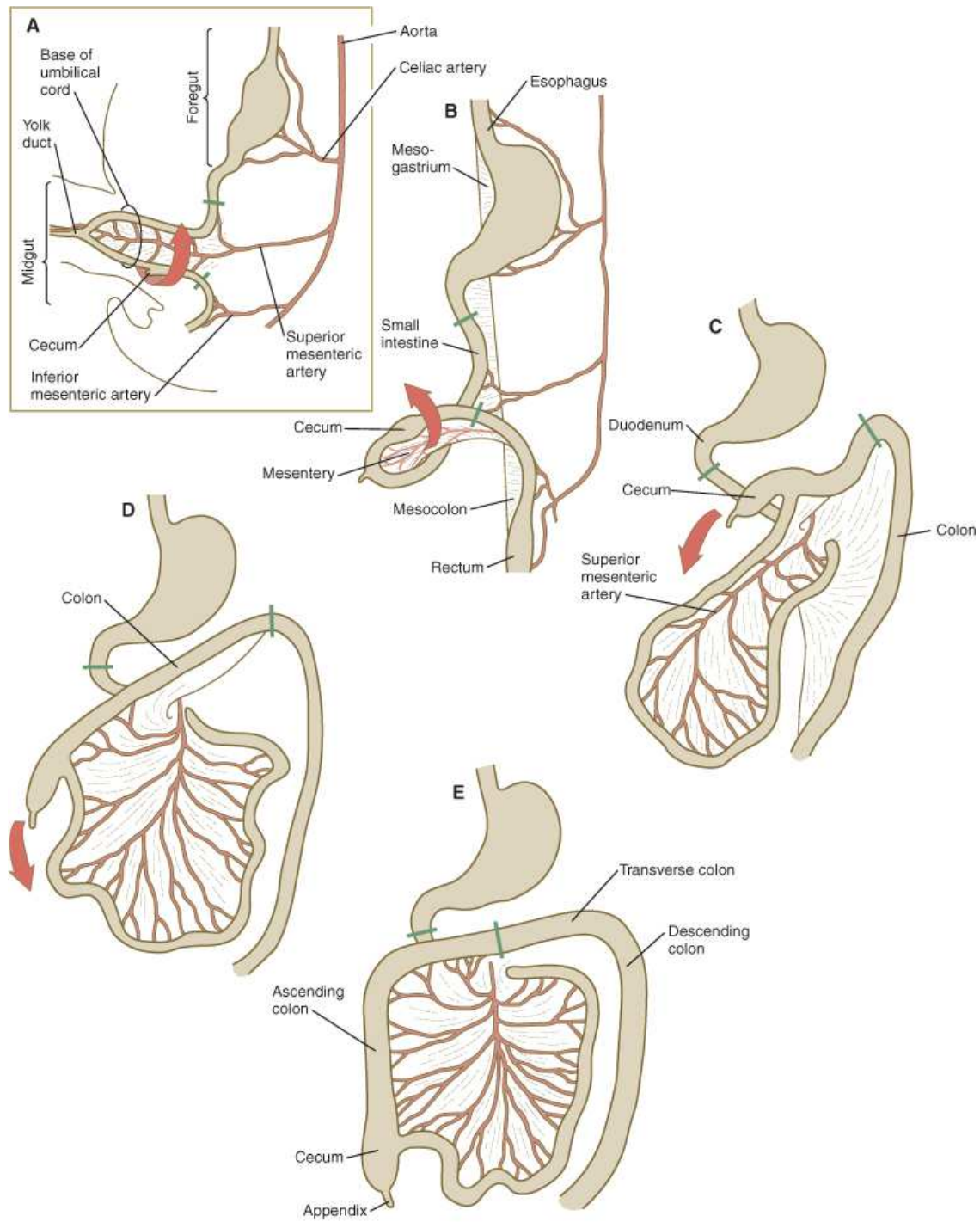
- # **Its apex is connected to the definitive yolk sac by the vitelline duct.**

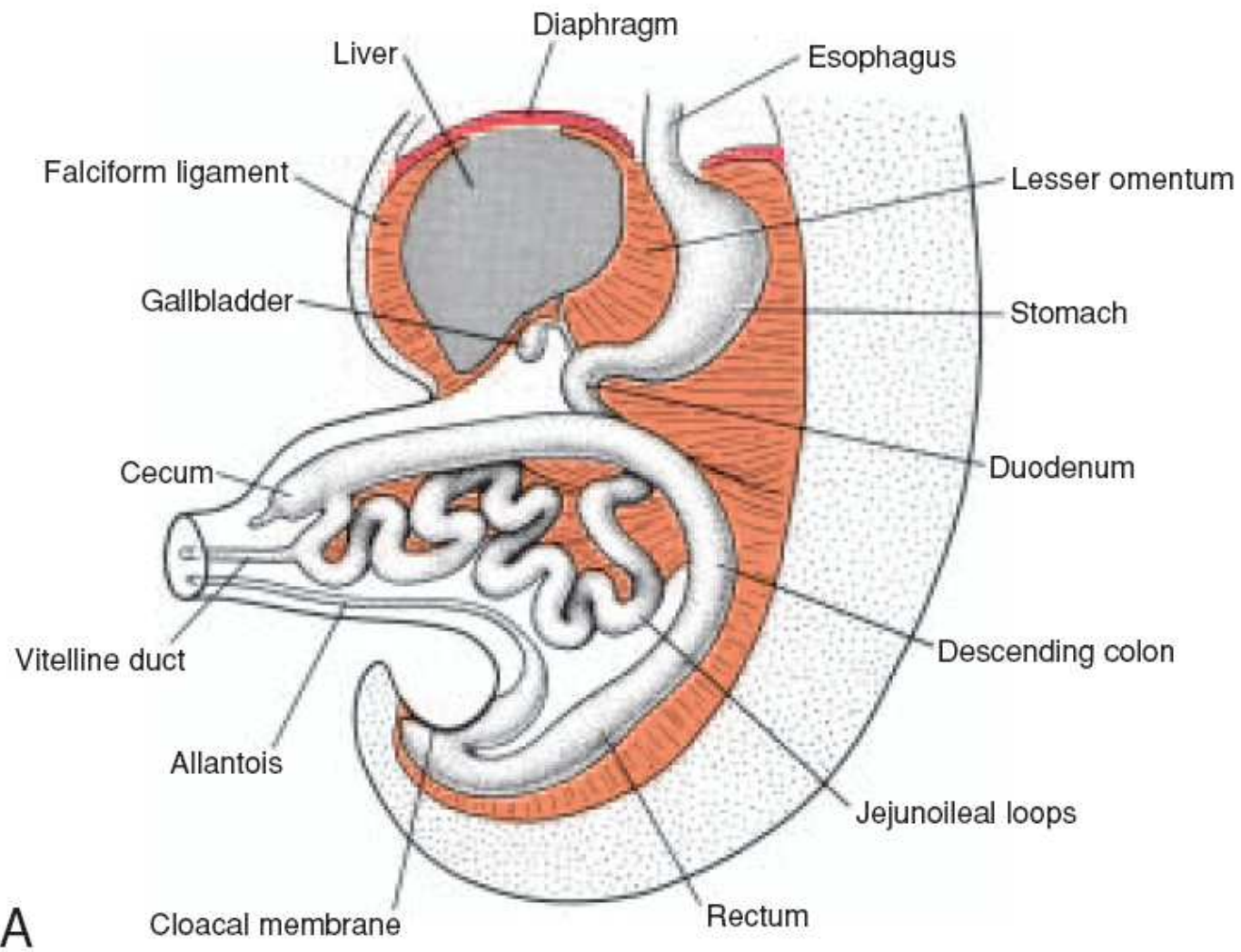
- # **The caecum appears as a bud in the beginning of the caudal limb.**

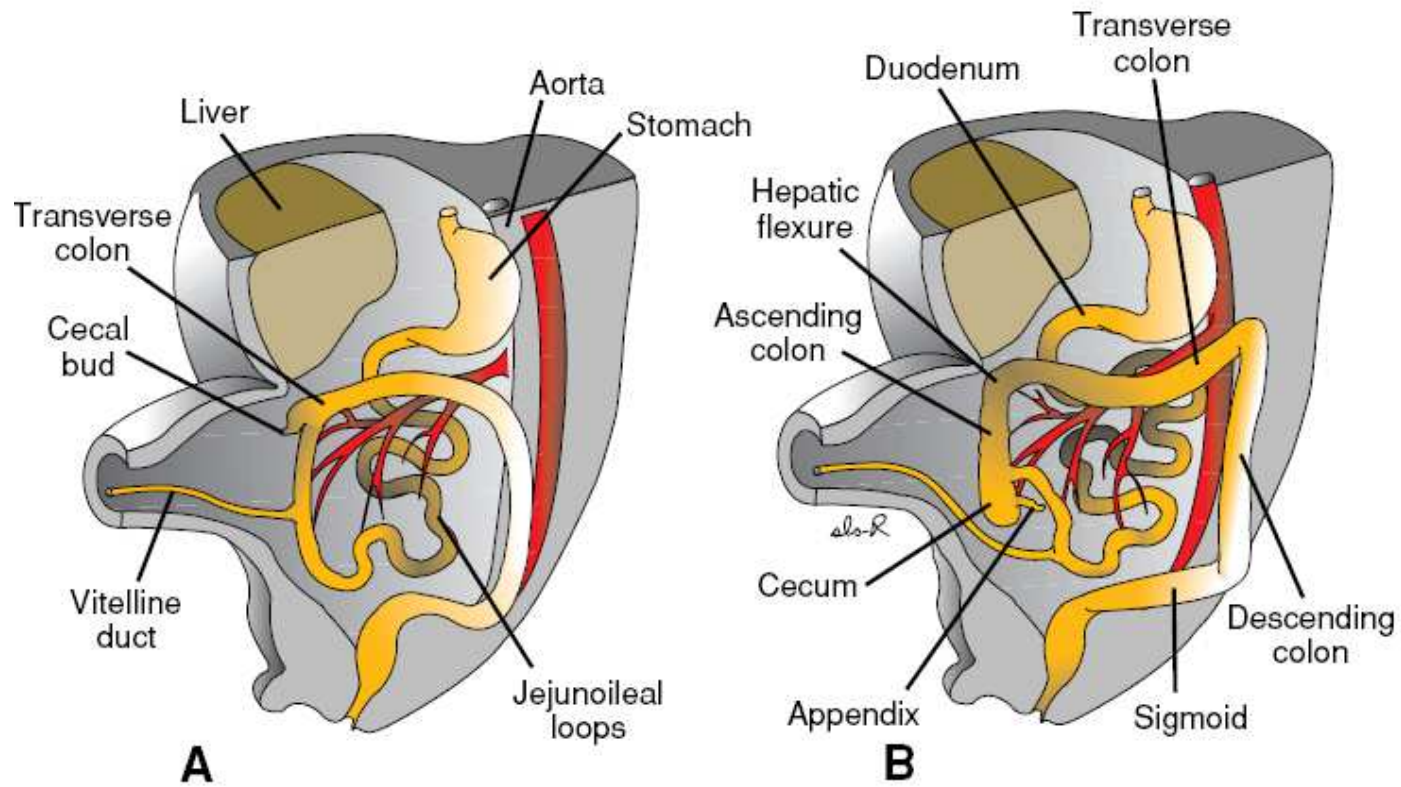


Changes in the gut loop:

- There is rapid elongation and coiling of the loop which together with the enlarging liver causes herniation of the loop through the umbilicus to the umbilical cord (**physiological umbilical hernia**) which lasts from the 6th week to the end of the 10th week of the intrauterine life.
- Rotation of the limb occurs during its herniation about 90 anti-clockwise bringing the cranial limb to the Rt. and the caudal limb to the Lt.
- Reduction of the hernia occurs at the end of the 10th week together with another rotation 180 anti-clockwise.
- The 1st part to return is the jejunum which passes to the left side of the abdomen and the remaining parts pass more and more to the right. The caecal bud is the last part to return and acquires a subhepatic position then it descends to the right iliac fossa.





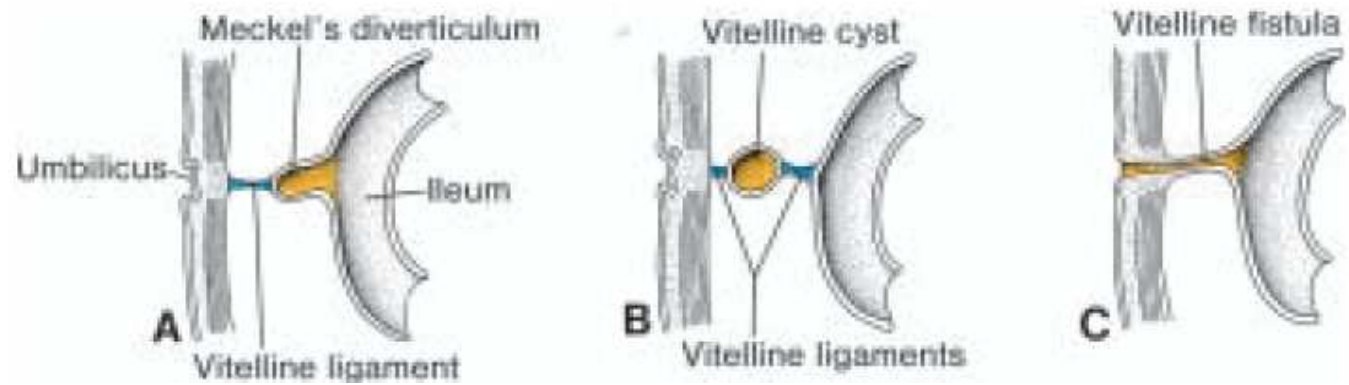
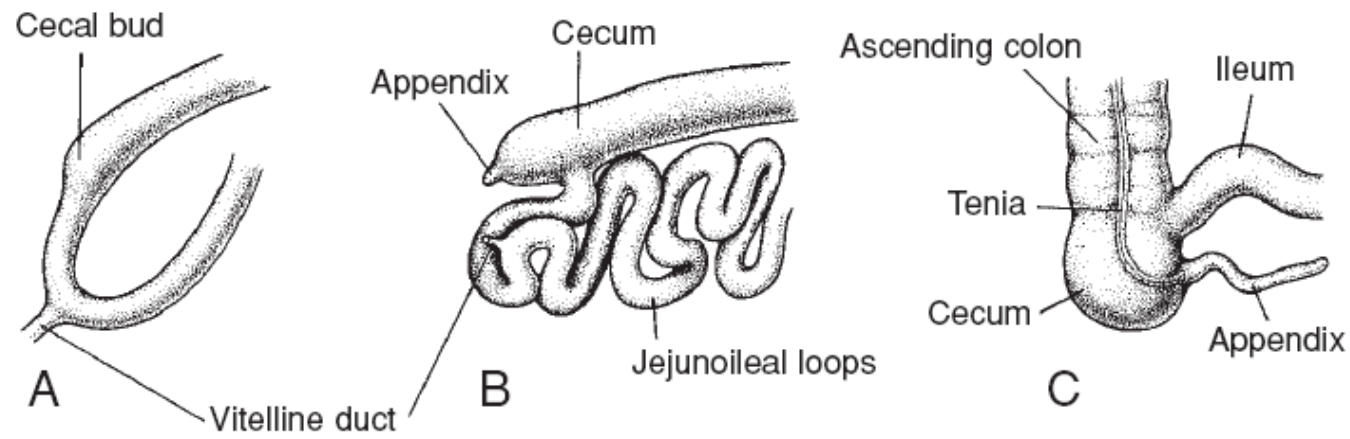


- During descent of the caecum, the distal end of the caecal bud forms a narrow diverticulum, the appendix.
- Absorption of dorsal mesentery occurs only in the region of ascending colon.
- During the 6th week, there is obliteration followed by absorption of the vitelline duct.

Anomalies of the mid-gut:

1- Remnants of the vitelline duct:

- a- Meckel's diverticulum: persistent proximal part of the duct.
- b- Vitelline cyst: persistent middle part of the duct.
- c- Vitelline or umbilical fistula: persistence of the whole duct connecting the small intestine to the anterior abdominal wall.



d- Vitelline ligament: persistent fibrosed vitelline duct.

2- Congenital umbilical hernia (omphalocele): the loops do not return to the abdomen and remain in the umbilical cord.

3- Abnormal rotation of the mid-gut loop:

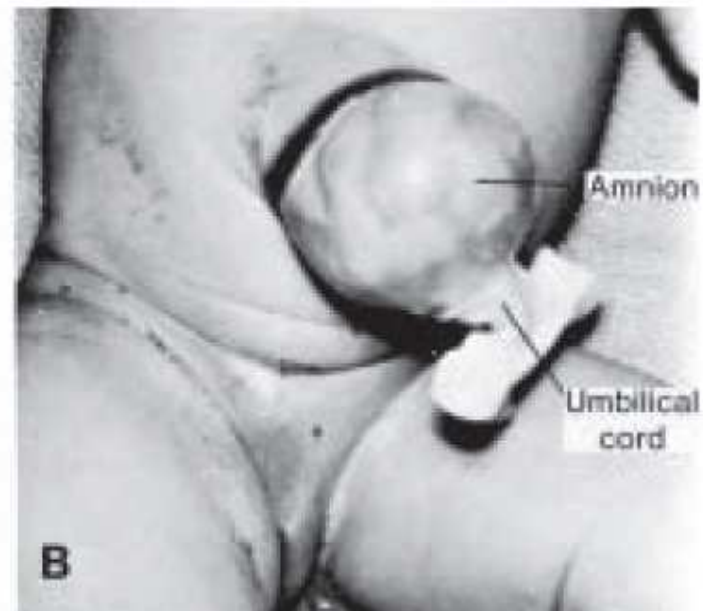
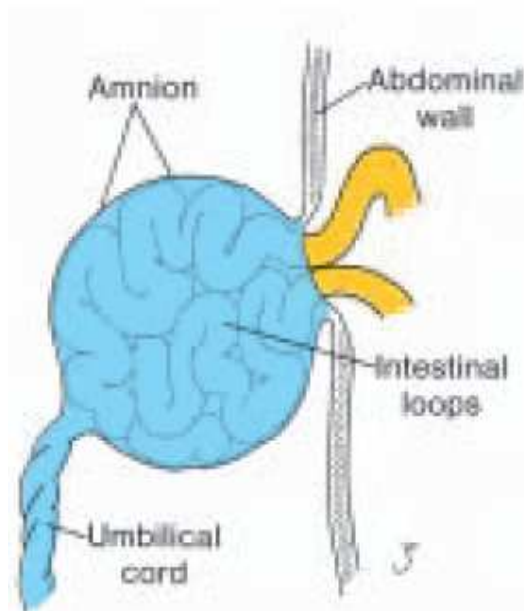
a- If rotation occurs only 90, the colon will lie on the left side and the small intestine to the right.

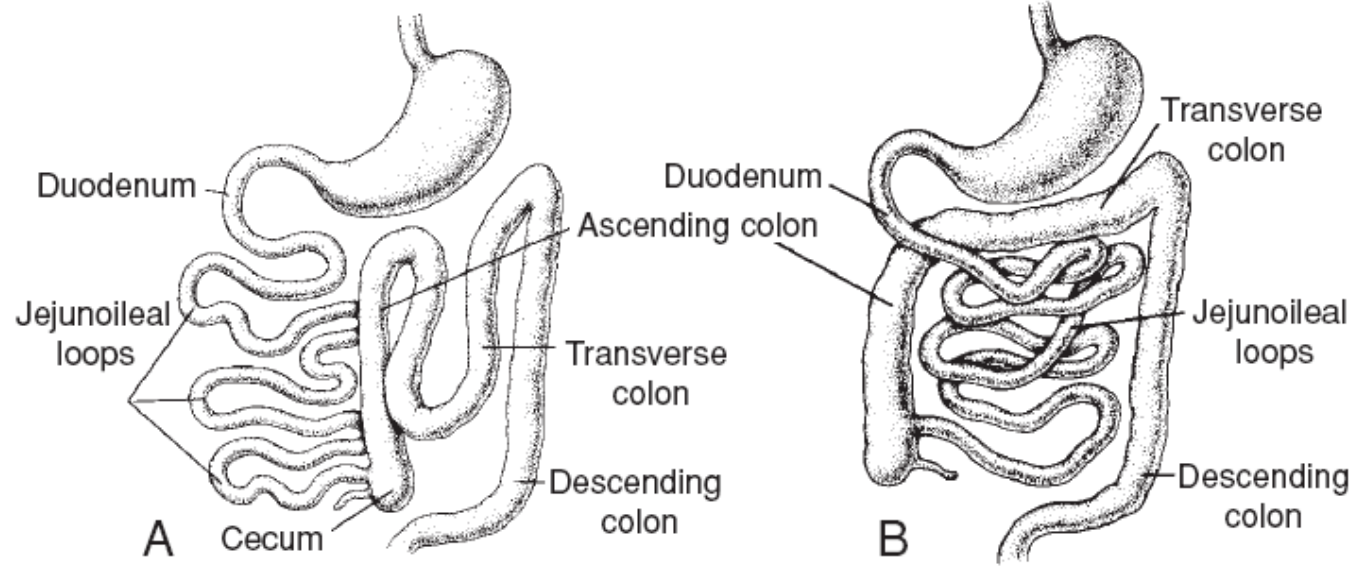
b- If rotation is reversed, the transverse colon will lie behind the duodenum.

4- Persistent mesentry of ascending colon.

5- Sub-hepatic colon.

6- Atresia or stenosis may occur anywhere along the intestine.





HIND-GUT

Derivatives:

1- mucosal lining of the GIT from the distal 1/3 of transverse colon to the upper 1/2 of anal canal.

2- Lining of the urinary bladder and urethra.

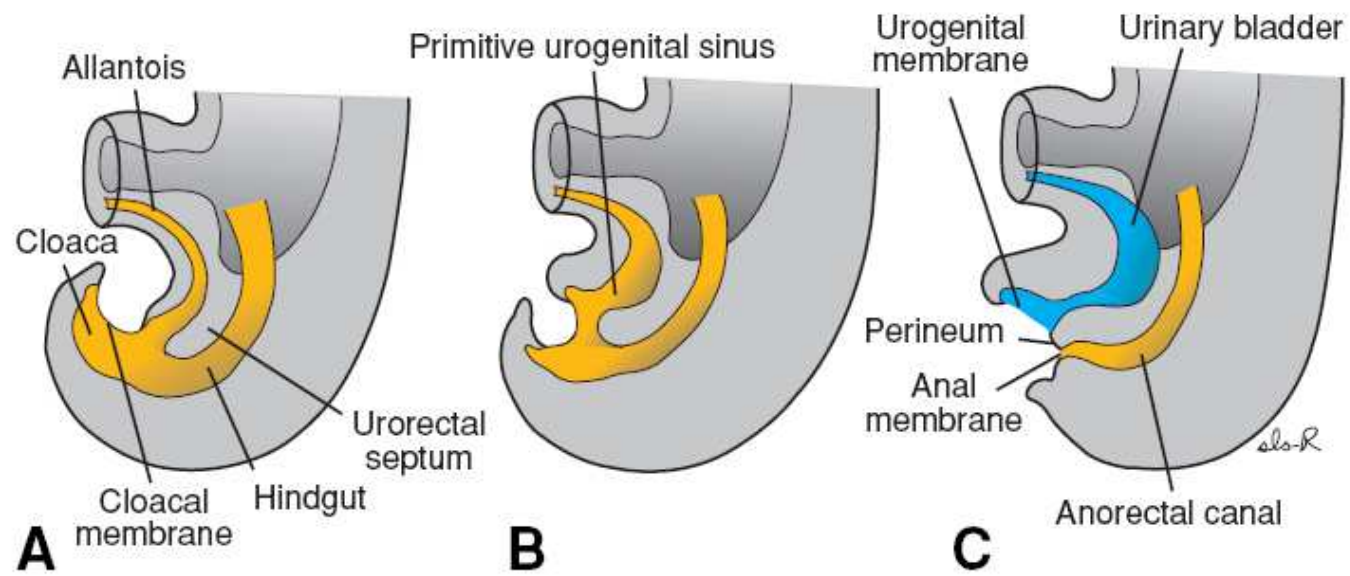
- The proximal part of the hind-gut cranial to the allantois gives rise to the left 1/3 of transverse colon, descending colon and sigmoid colon.

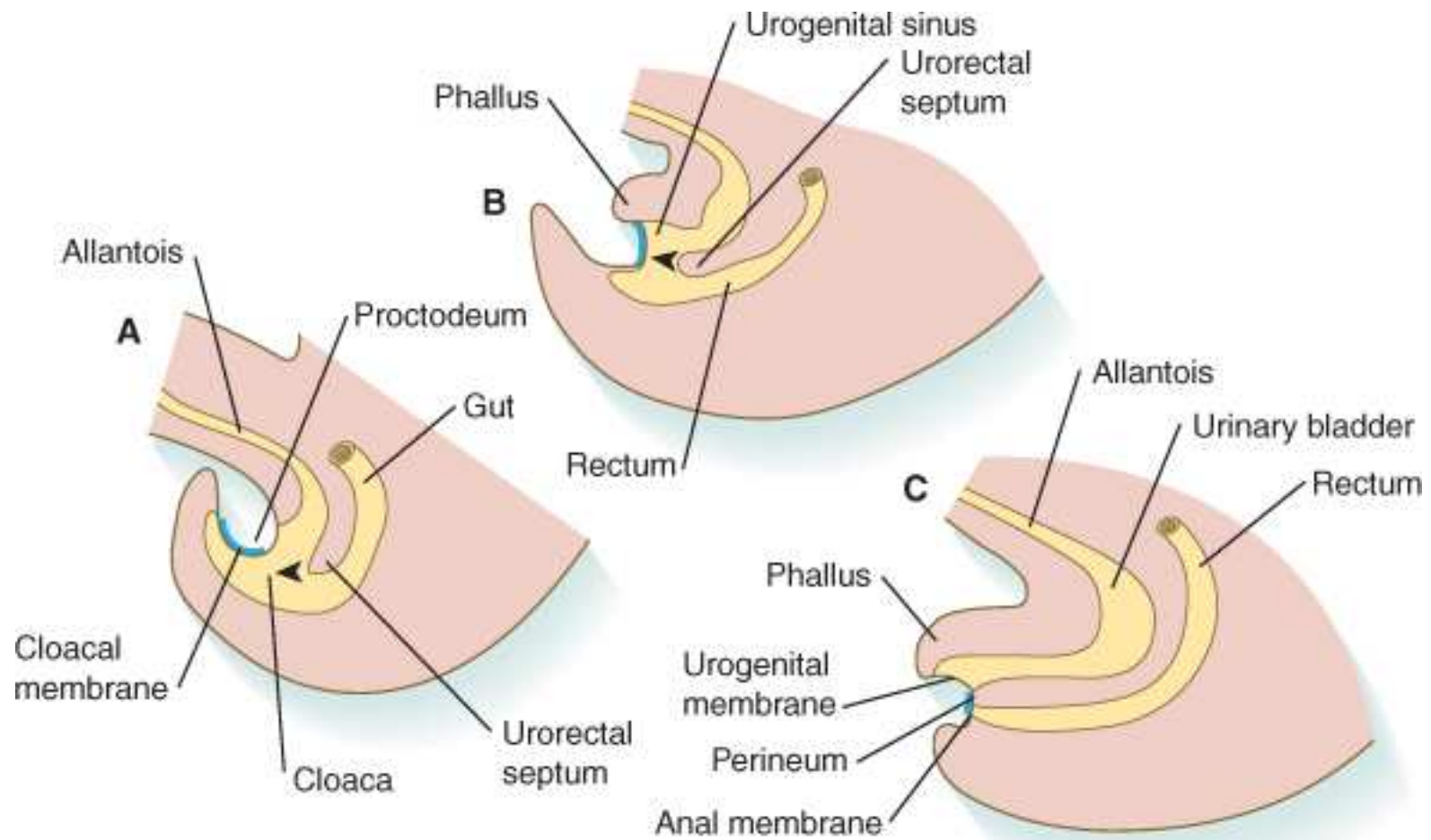
- The distal part of the hind-gut (caudal to the allantois) is dilated to form the cloaca.

***Dorsally, it receives the proximal part of the hind-gut.**

***Ventrally, it receives the allantois.**

***Caudally, it is closed by the cloacal membrane.**





- In the angle between the allantois and hind-gut, the mesoderm grows caudally pushing the endoderm forming a partition called the uro-rectal septum which reaches the cloacal membrane and fuses with it.

- The cloaca becomes divided into:

- 1- Ventral part (Primitive uro-genital sinus): forms parts of the uro-genital system.

- 2- Dorsal part: forms the mucosa of the rectum and upper part of anal canal.

- The cloacal membrane becomes divided into:

- 1- Ventral part: uro-genital membrane.

- 2- Dorsal part: anal membrane.

- The site of fusion of the uro-rectal septum with the cloacal membrane corresponds to the perineal body.

- The mesoderm around the anal membrane proliferates to form anal folds which surround an ectodermal depression called proctodeum, at the bottom of which lies the cloacal membrane.

In the 9th week, the anal membrane ruptures forming communication between the 2 parts of anal canal. The site of the membrane is represented in the anal canal by the pectinate line.

Anomalies of the hind-gut:-

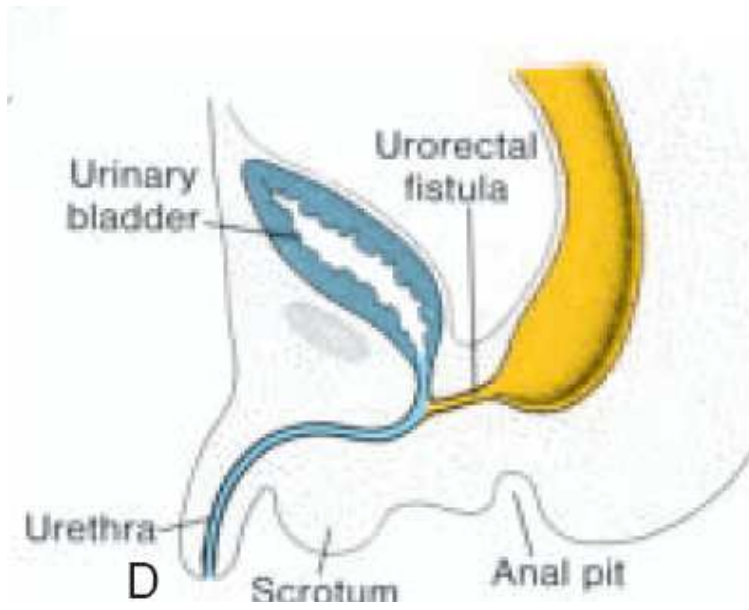
1- Congenital megacolon (Hirschsprung disease): absence of parasympathetic ganglia from the wall of the colon (from neural crest) leading to absence of peristalsis and distention above this aganglionic segment.

2- Imperforate anus: due to persistent anal membrane.

3- Rectal atresia: a thick septum separates rectum from anal canal.

4- Rectal fistula: due to incomplete uro-rectal septum:

- In females: recto-vaginal fistula.**
- In males: recto-vesical fistula.**

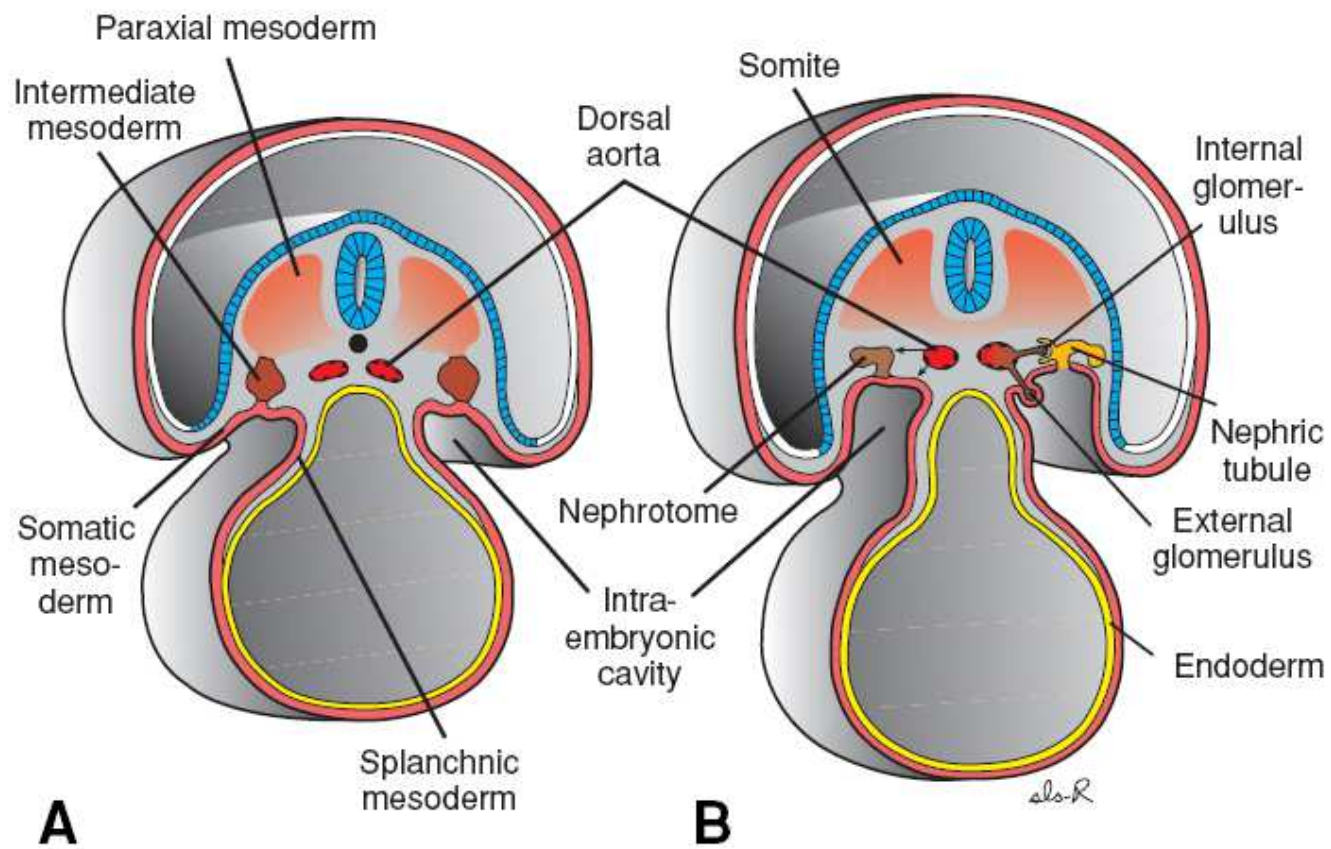


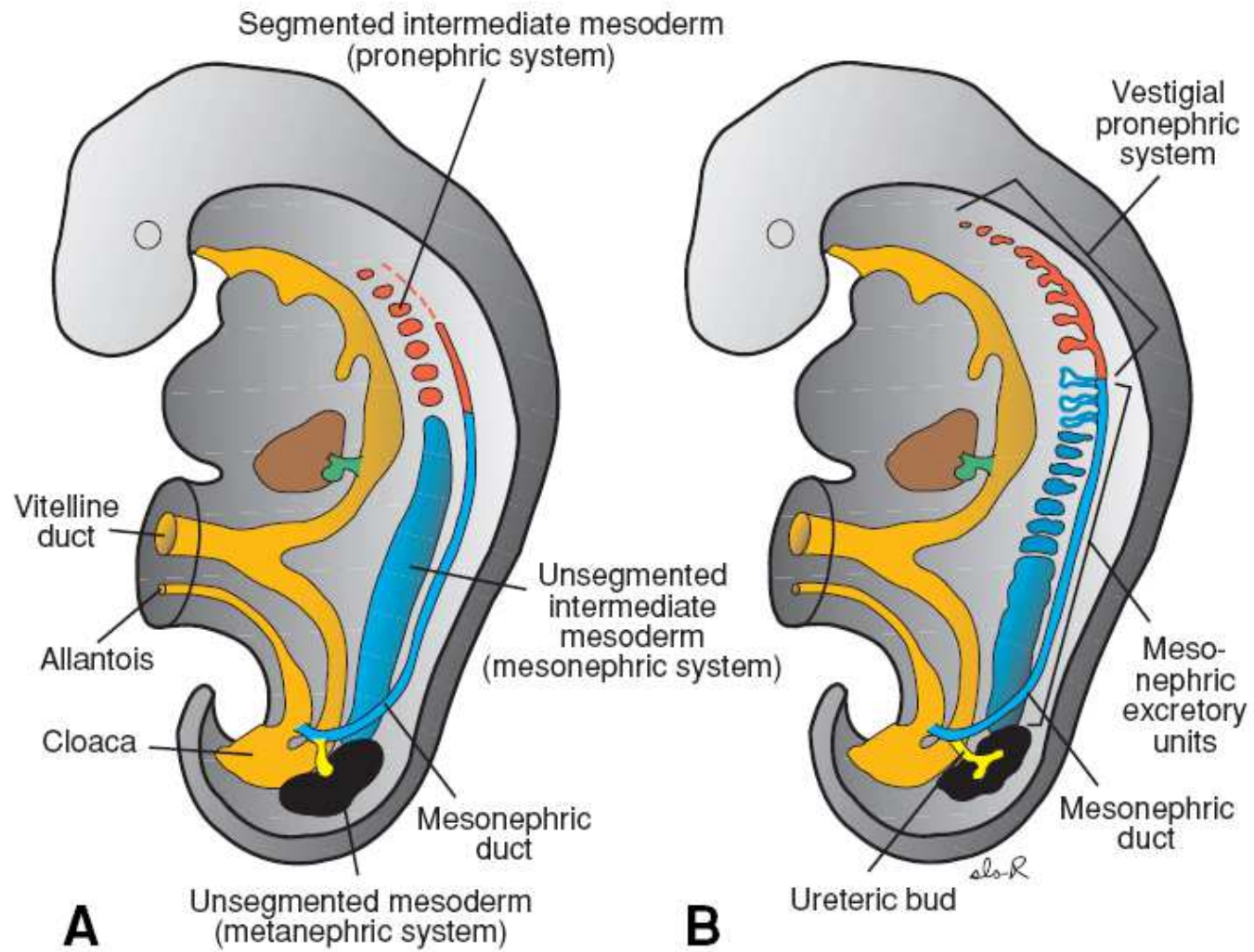
URINARY SYSTEM

- It develops from the intermediate mesoderm.
- Three successive kidneys are formed during intrauterine life in human.
 - These are: Pronephros, mesonephros and metanephros or permanent kidney.

Pronephros

- It is the 1st kidney to appear.
- At the beginning of the 4th week, it develops in the cervical region in the form of 7 to 10 solid masses known as nephrotomes.
- These nephrotomes regress before more caudal ones are formed.
- By the end of the 4th week, pronephric system disappeared.





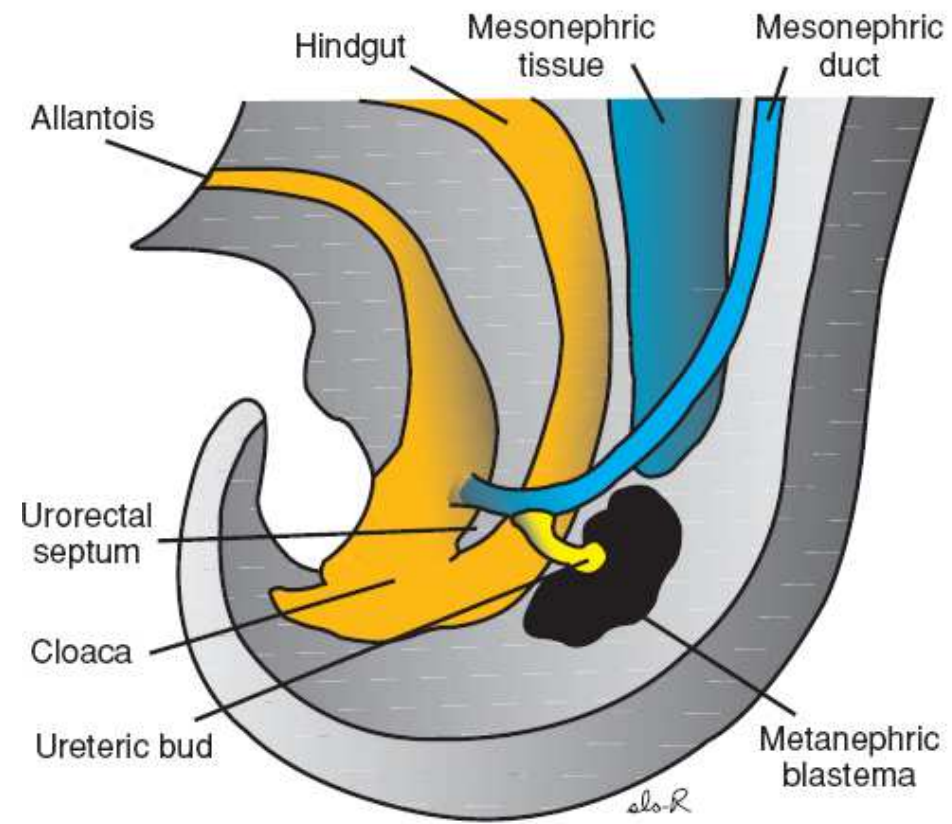
Mesonephros

- It is the 2nd kidney to appear.
- It develops in the thoracic and upper lumbar regions of the intermediate mesoderm during regression of the pronephric tubules.
- The mesoderm of the intermediate cell mass gives rise to mesonephric tubules.
- Each tubule elongates forming an S-shaped loop which acquires a glomerulus at its medial end forming a Bowman's capsule.
- Laterally, the tubules join a collecting duct known as mesonephric or Wolffian duct.
- In the middle of the 2nd month, the mesonephros forms a large ovoid organ on each side of midline. Since the gonad develops on its side the ridge formed called urogenital ridge.

- While the caudal tubules are still differentiating, the cranial ones start to degenerate and by the end of the 2nd month the majority disappear.
- In the male, a few of the caudal tubules and the mesonephric duct persist and participate in formation of genital system.

Metanephros

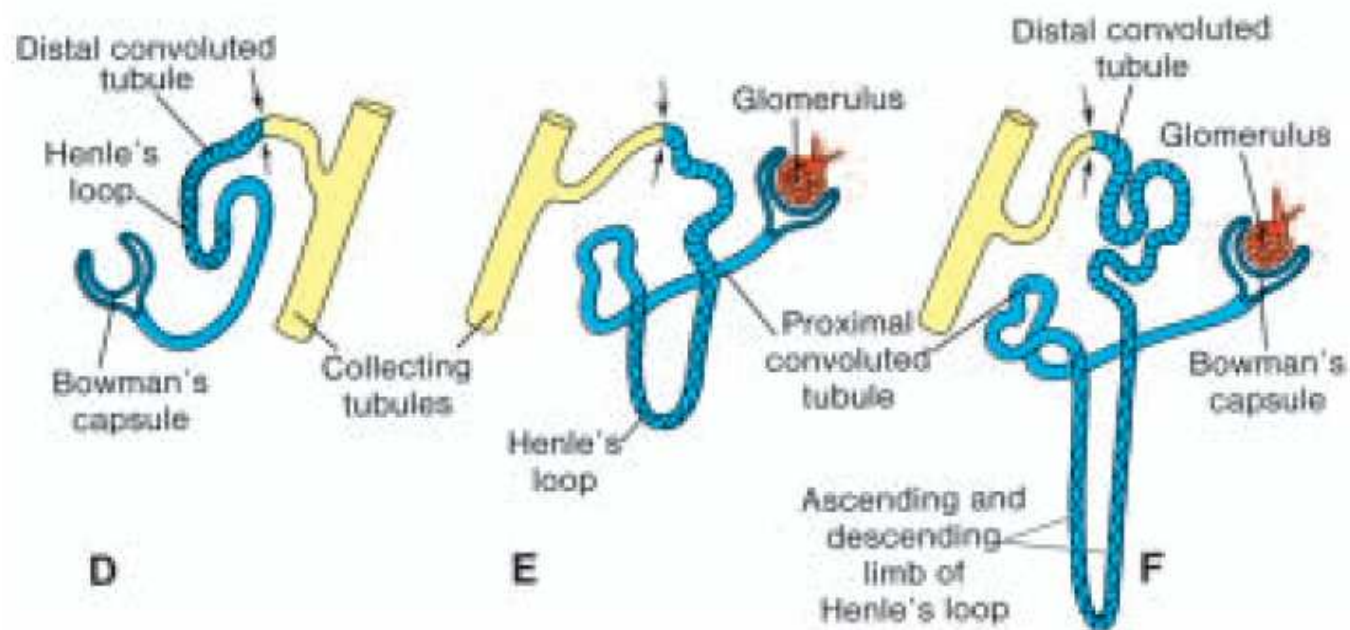
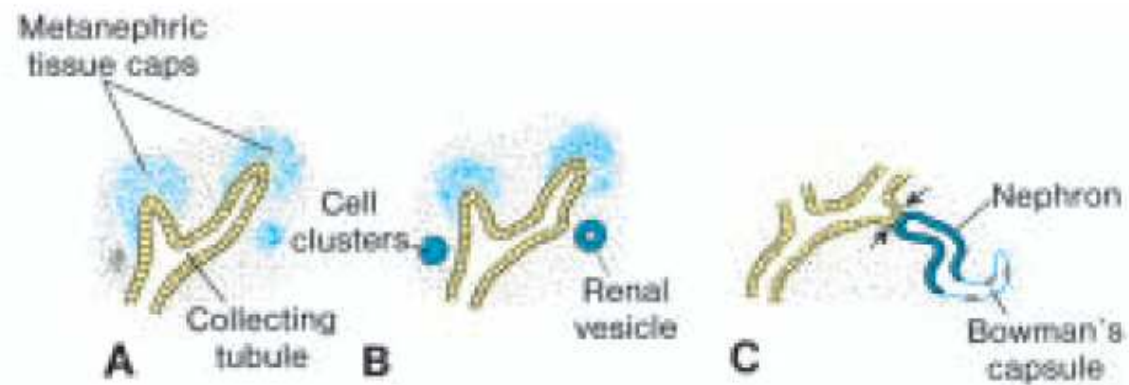
- It is the 3rd or permanent kidney.
- It appears in the 5th month in the lower lumbar and sacral regions of the intermediate cell mass.
- It develops from 2 sources:
 - 1- The collecting system: develops from the ureteric bud.
 - * The bud arises as an outgrowth from the mesonephric duct close to its entrance to the cloaca.



- * The cranial end of the bud grows up and penetrates the metanephric tissue, which forms a cap over its distal end.**
- * Then, the cranial end dilates forming the primitive renal pelvis and the rest of the bud elongates forming the ureter.**
- * The pelvis divides continuously into several generations of divisions, up to 12 or more generations, penetrating metanephric tissue forming the major calyces, minor calyces and collecting tubules.**

2- Excretory system: develops from the metanephric tissue.

- * The metanephros becomes segmented repeatedly by the branching ureteric bud.**
- * Each newly formed collecting tubule becomes covered by a metanephric tissue cap.**
- * Cells of the tissue cap form small vesicles, renal vesicles, which give rise to S-shaped tubules that form the nephrons.**



- * One end of the nephron forms the Bowman's capsule that acquires a glomerulus of capillaries formed by local angiogenesis.**
- * The other end forms an open connection with one of the collecting tubules.**
- * Continuous lengthening of the tubule results in the formation of the proximal convoluted tubule, loop of Henle and distal convoluted tubule.**
- Nephrons are formed until birth, at which time there are about 1 million in each kidney.**
- Urine production begins early in gestation by about 10th week (after formation of glomerular capillaries). It passes into the amniotic cavity and mixes with the amniotic fluid. The fluid is swallowed by the fetus and recycles through the kidneys. During fetal life, the kidneys are not responsible for excretion of waste products.**

Changes in the developing kidney:

- 1- Change in shape: at birth the kidneys have a lobulated appearance which disappears during infancy as the result of growth of the nephrons.**
- 2- Change in position: at 1st the kidney is located in the pelvis, later it shifts to the abdomen due to growth of the body in the lumbar and sacral regions.**
- 3- Change in blood supply: in the pelvis, it receives its blood supply from the median sacral artery. During its ascent it is supplied by arteries from the common iliac artery then the aorta at successively higher levels. The lower vessels usually degenerate.**
- 4- Change in direction: at 1st the hilum looks forwards, then the kidney rotates so that the hilum looks medially.**

Congenital anomalies of the kidney:

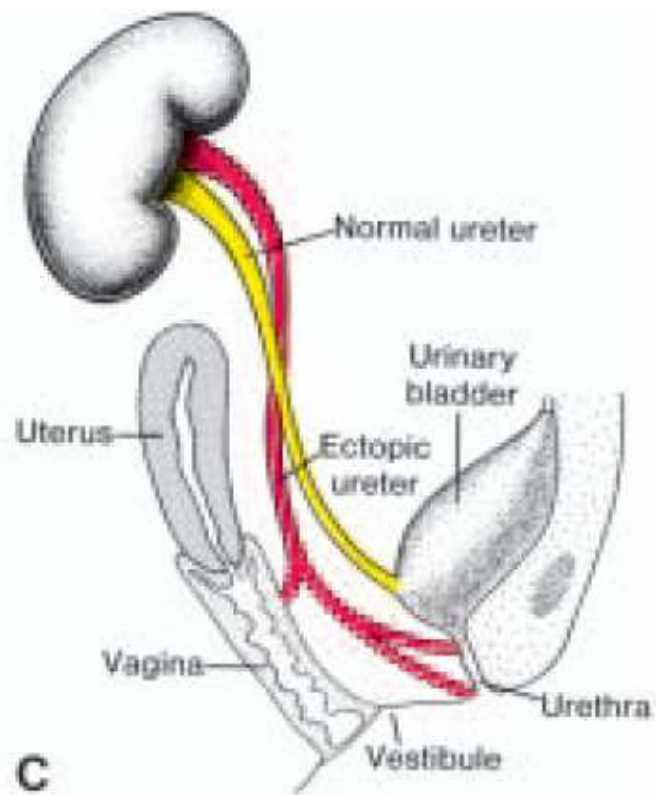
- 1- Renal agenesis: which may be unilateral or bilateral.**
- 2- Congenital cystic kidney: caused by failure of union between some collecting and excretory tubules.**
 - It may be polycystic kidney or solitary cyst.**
- 3- Double kidney: caused by early splitting of ureteric bud.**
- 4- Pelvic kidney: caused by failure of the kidney to ascend.**
- 5- Horseshoe kidney: the kidneys fuse at their lower poles.**
- 6- Persistent fetal lobulation.**
- 7- Aberrant renal artery: caused by persistence of one or more of transient arteries.**



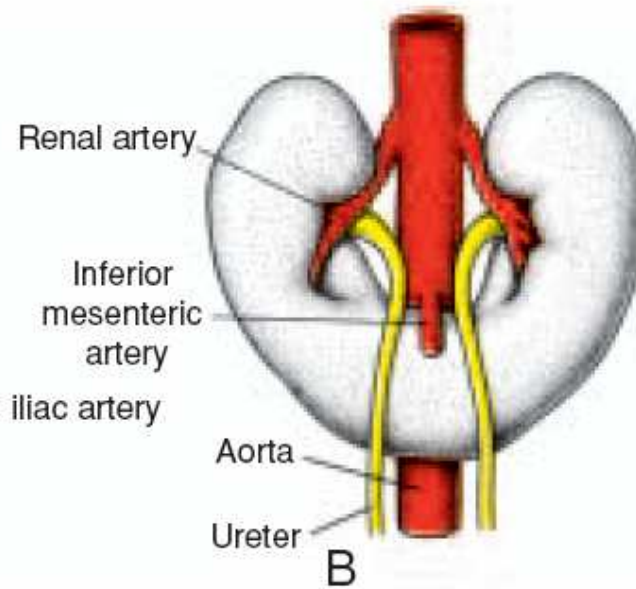
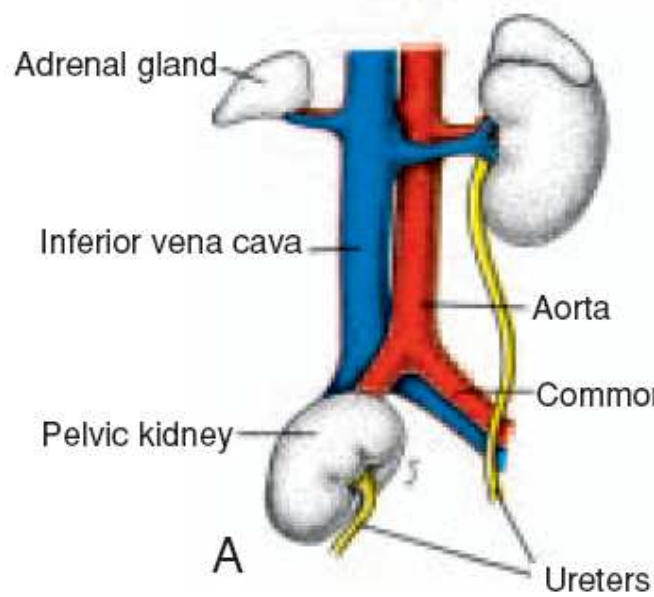
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B

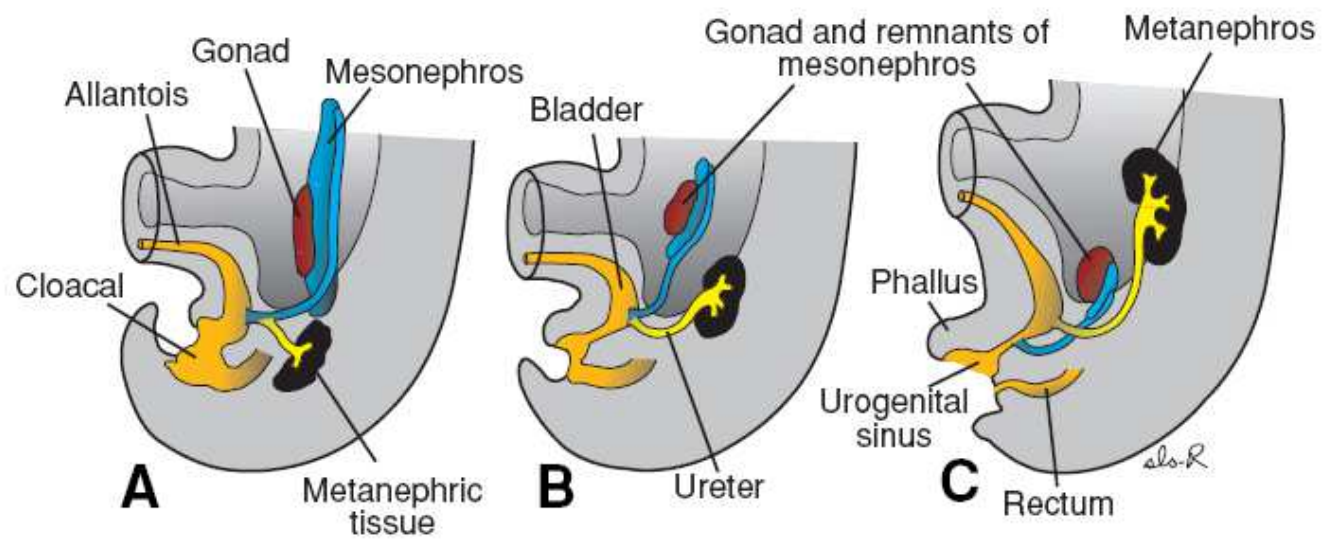


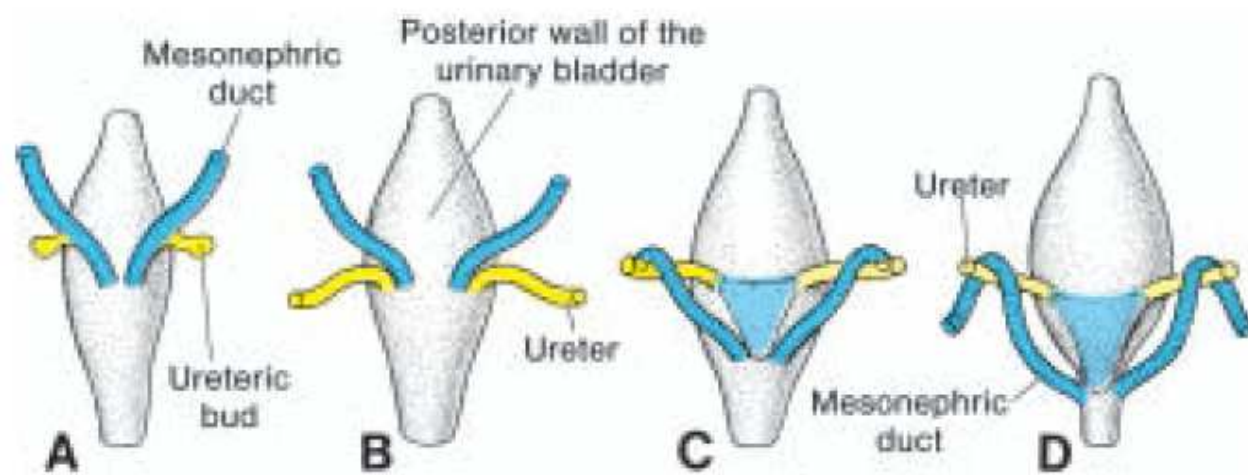
C



THE URETER

- It develops from the ureteric bud which arises from the mesonephric duct.
- The caudal part of the mesonephric duct (below the ureteric bud) is absorbed into the ventral part of the cloaca to form the trigone of the urinary bladder. As the result, the 2 ureteric buds and the 2 mesonephric ducts open separately into the urinary bladder.
- As the result of ascent of the kidneys, the ureters elongate.





URINARY BLADDER

- It is derived from 2 sources:

- 1- The endoderm of part of the cloaca:

- The cloaca is divided by the urorectal septum into 2 parts:

- a- The primitive urogenital sinus: is the ventral part.

- It is closed caudally by the urogenital membrane.

- It is connected to the mesonephric ducts and the allantois which extends to the umbilicus.

- b- The anorectal canal: that is closed caudally by the anal membrane.

- The primitive urogenital sinus differentiates into 3 portions:

- a- The vesical portion: the cranial largest part.

- Its apex is connected to the allantois.

- In male: it gives the epithelium of most of the urinary bladder and part of the prostatic urethra.
In female: it gives the epithelium of most of the urinary bladder and the whole urethra.

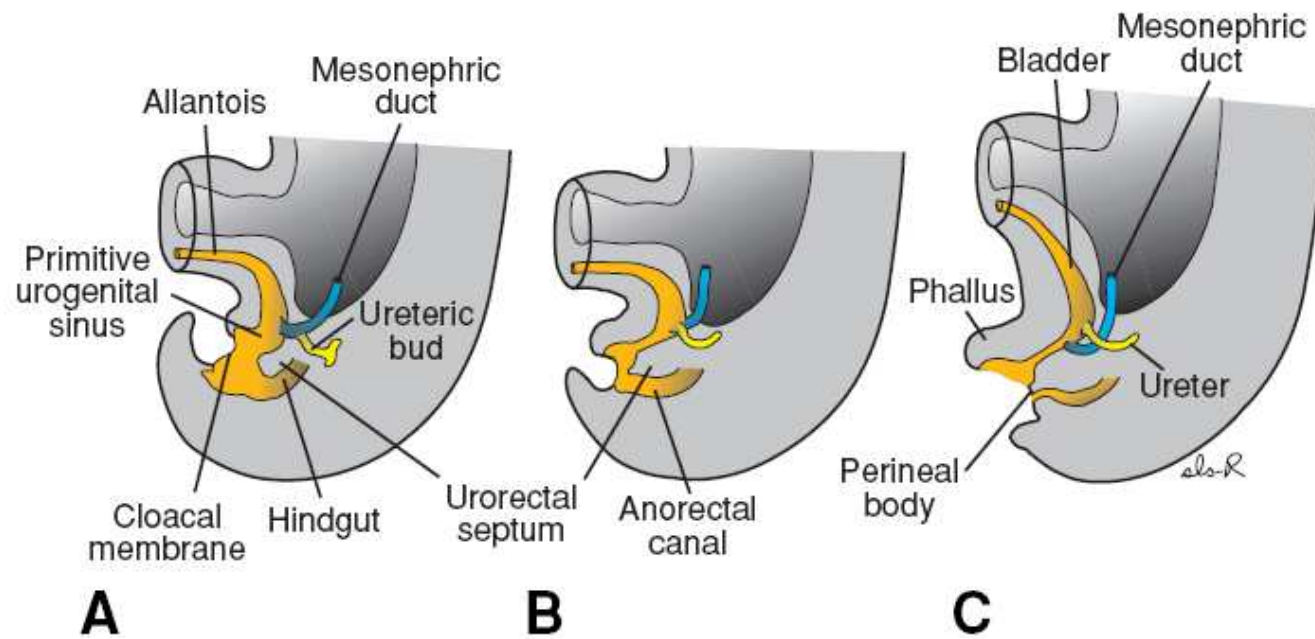
- The intraembryonic part of the allantois constricts forming the urachus, a fibrous cord that connects the apex of the bladder with the umbilicus. In adults, the urachus forms the median umbilical ligament.

b- Pelvic portion: the middle narrow part. The mesonephric ducts are attached between the vesical and pelvic portions.

c- Phallic portion: the caudal part which is closed by the urogenital membrane.

2- The mesoderm of the lower part of the mesonephric ducts:

- The caudal ends of the mesonephric ducts below the ureteric buds are absorbed forming the trigone of the urinary bladder.



- As the kidneys ascend, the ureteric orifices are dragged craniolaterally while the mesonephric ducts remain at a lower level.

N.B.

- The rest of the bladder wall is derived from the surrounding splanchnic mesoderm.

- At birth, the urinary bladder is an abdominal organ. It becomes a pelvic organ at puberty.

- As the trigone of the bladder develops from the mesonephric ducts, it is mesodermal. With time, the mesodermal lining is replaced by endodermal epithelium that spread from the rest of the bladder.

Anomalies:

- 1- Ectopia vesica: the mucosa of the posterior bladder wall is exposed to the outside due to absence of the anterior wall together with the overlying anterior abdominal wall.

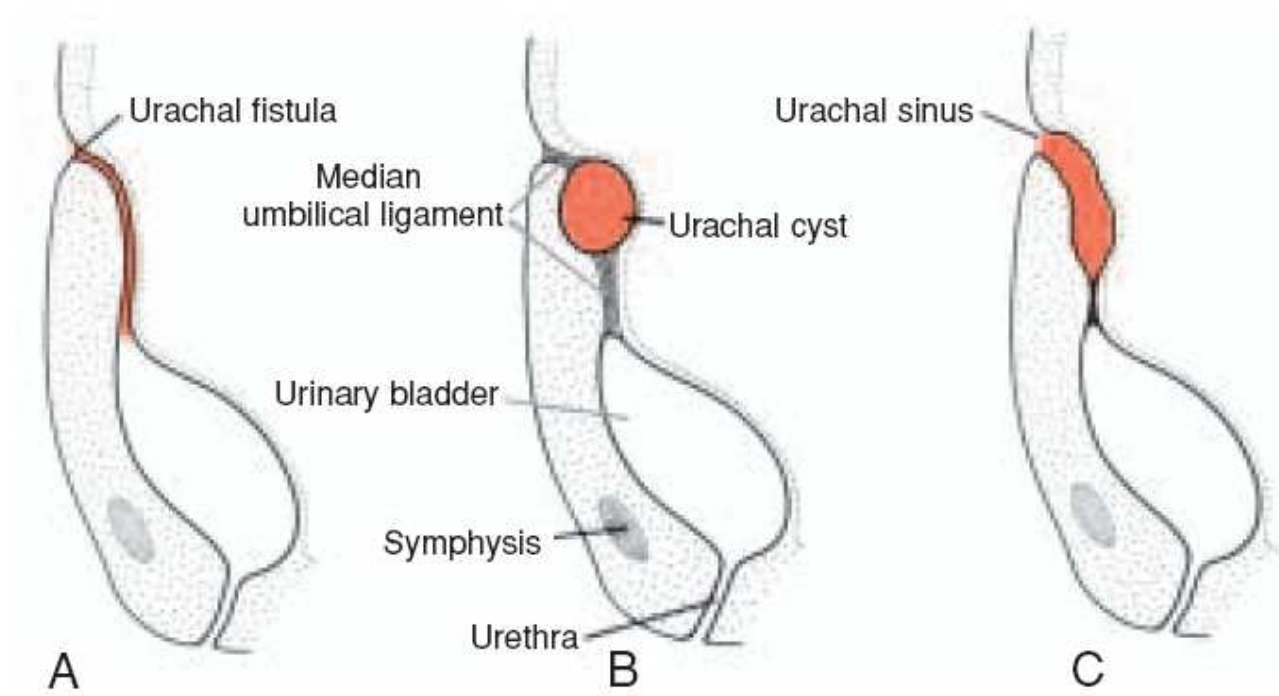
2- Patent urachus:

a- Urachal fistula: the allantois doesnot constrict and urine flow from the umbilicus.

b- Urachal sinus: patent upper part of the urachus.

c- Urachal cyst: cystic dilatation along the course of the urachus.

3- Recto-vesical fistula: caused by incomplete urorectal septum.



THE GENITAL SYSTEM

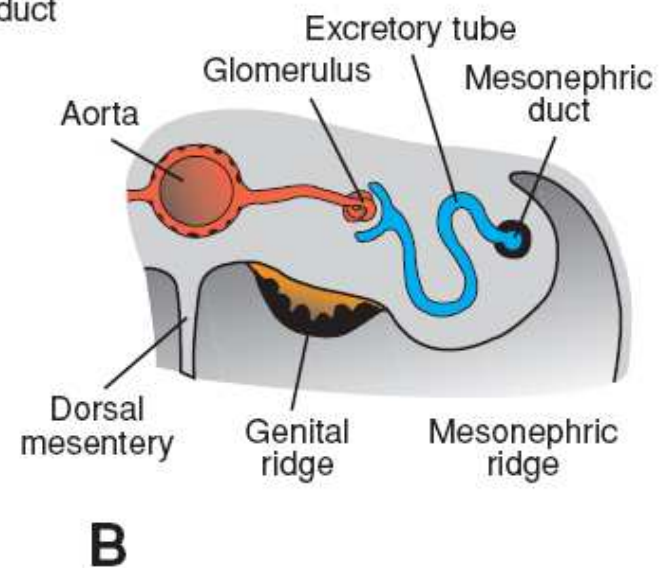
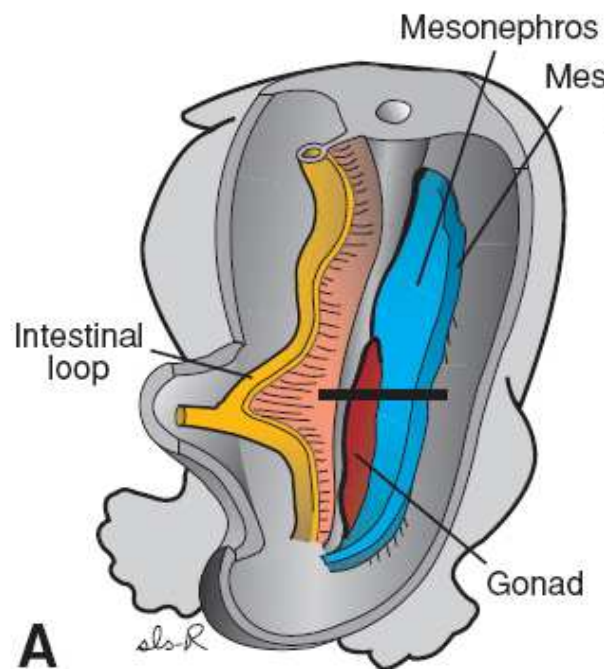
The genital system consists of:

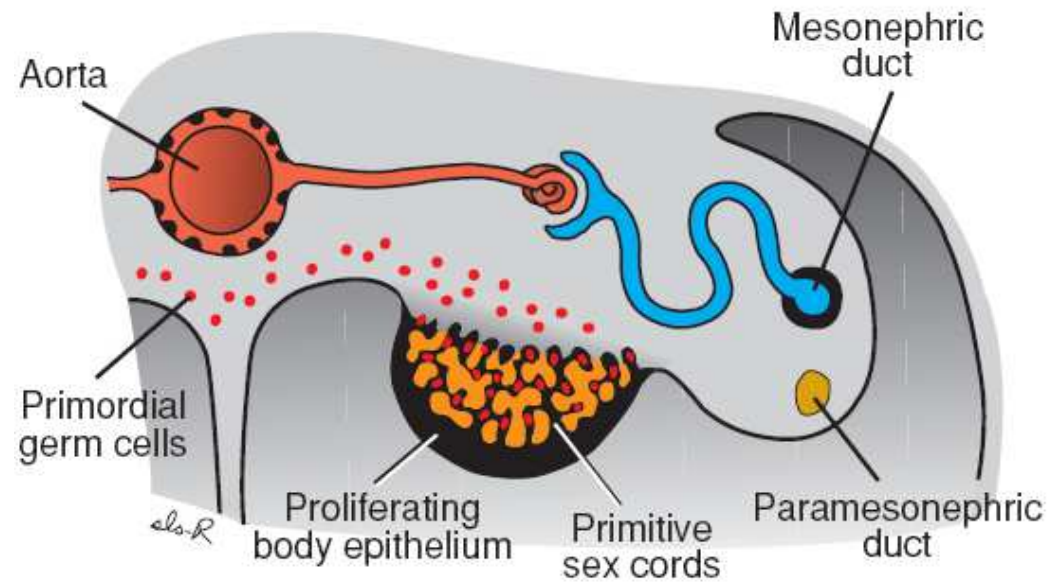
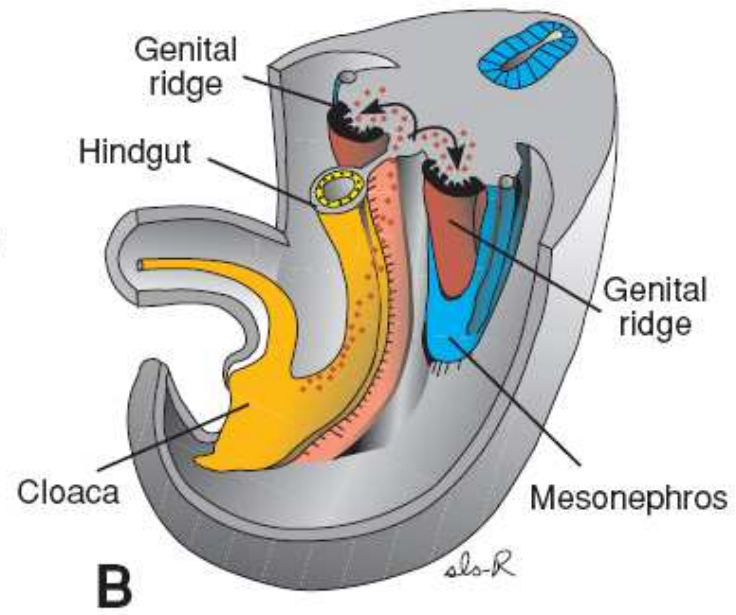
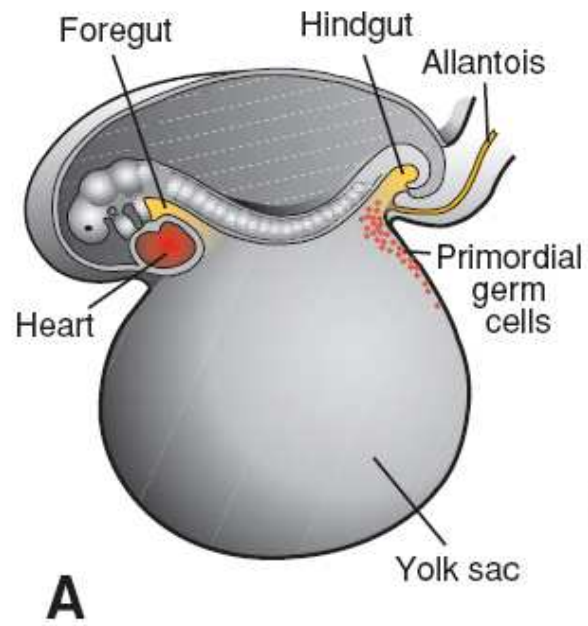
- a- Gonads or primitive sex glands.**
 - b- Genital ducts.**
 - c- External genitalia.**
- All the 3 components pass through an indifferent stage in which they may develop into either a male or a female.**
 - The SRY (sex determining region) gene on the Y chromosome produces testes-determining factor that regulates male sexual development.**

GONADS

Indifferent gonad:

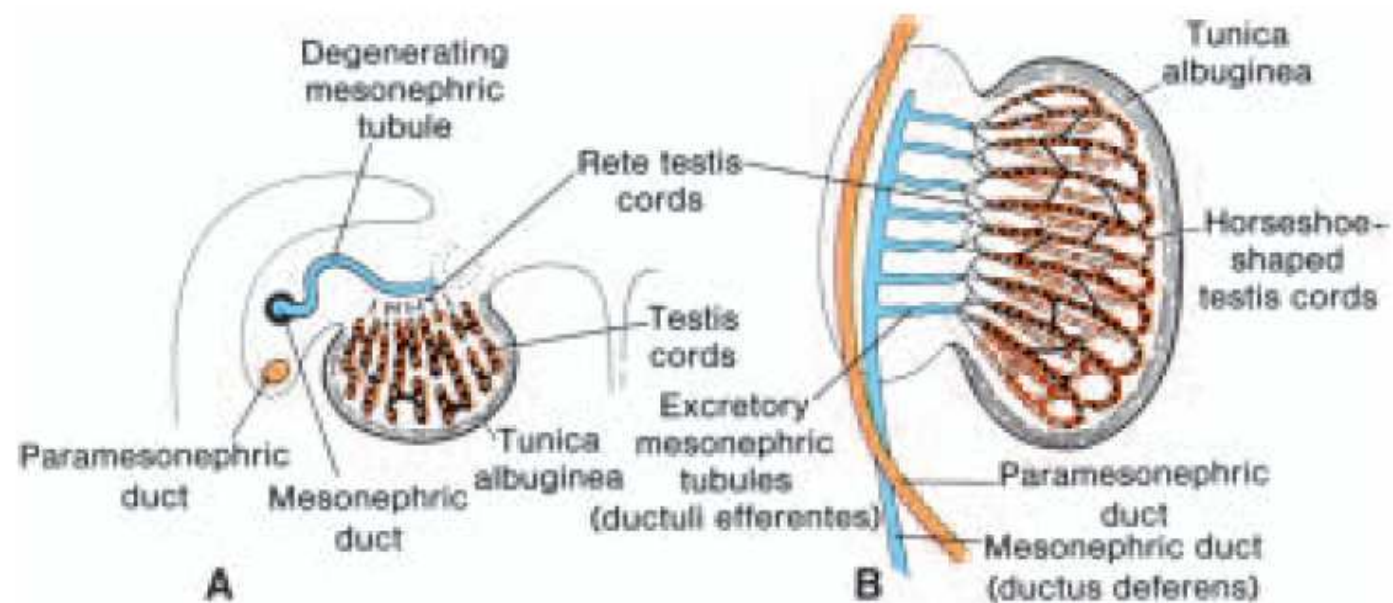
- The gonads appear on the 5th week as a pair of longitudinal ridges on the medial side of the mesonephros.
- They develop due to proliferation of the coelomic epithelium which penetrate the underlying mesoderm forming a number of solid cords, **primitive sex cords**. During this stage, it is impossible to differentiate between male or female although the sex is determined since fertilization.
- The primordial germ cells appear during the 4th week among the endoderm of the wall of the yolk sac close to the allantois.
- They migrate by amoeboid movement along the dorsal mesentery to reach the genital ridges where they become incorporated in the sex cords. They have inductive influence on the development of the gonad into ovary or testis.





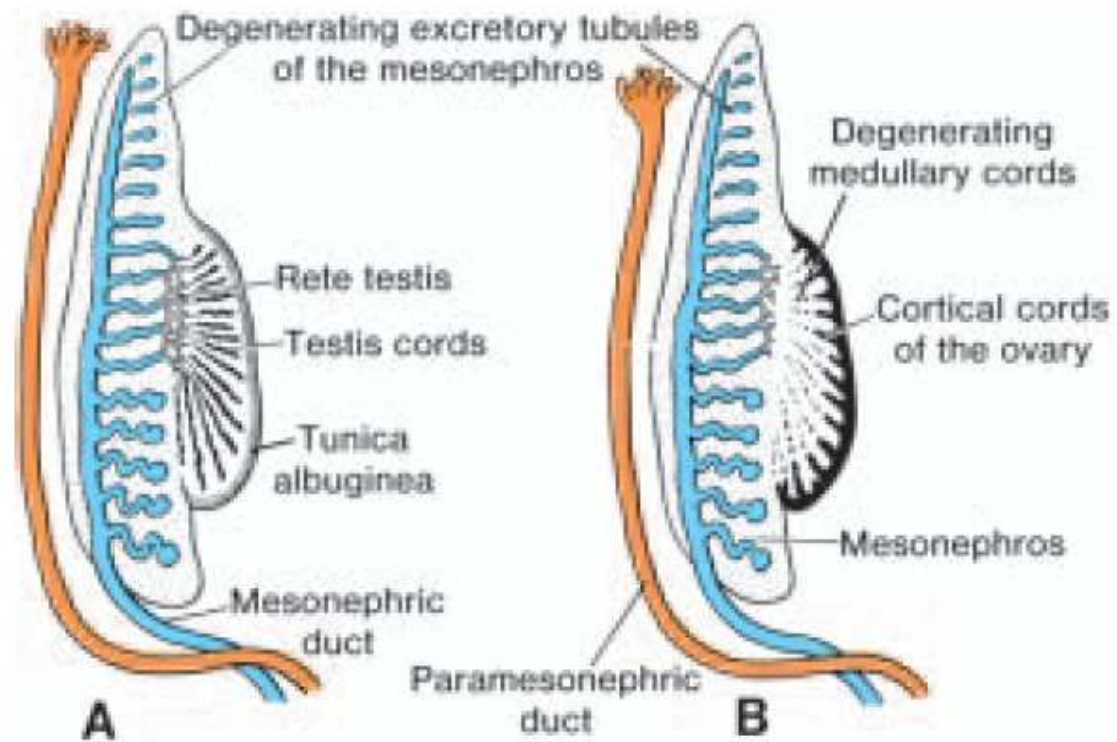
TESTIS:

- If the embryo is a male, the primordial germ cells carry XY sex chromosome which carry testis-determining factor (TDF) on the Y chromosome that stimulates the gonad to develop into a testis.
- The TDF induces the primitive sex cords to proliferate and penetrate deep into the medulla to form the testis or medullary cords. Near the hilum of the gonad, the cords break and anastomose into a network called rete testis.
- Later, a dense layer of connective tissue, the tunica albuginea, develops from the surrounding mesoderm isolating the testis cords from the surface epithelium.
- In the 4th month, the testis cords become horseshoe-shaped and develop into the seminiferous cords that contain 2 types of cells: a- primordial germ cells (endodermal): develops into spermatogonia.



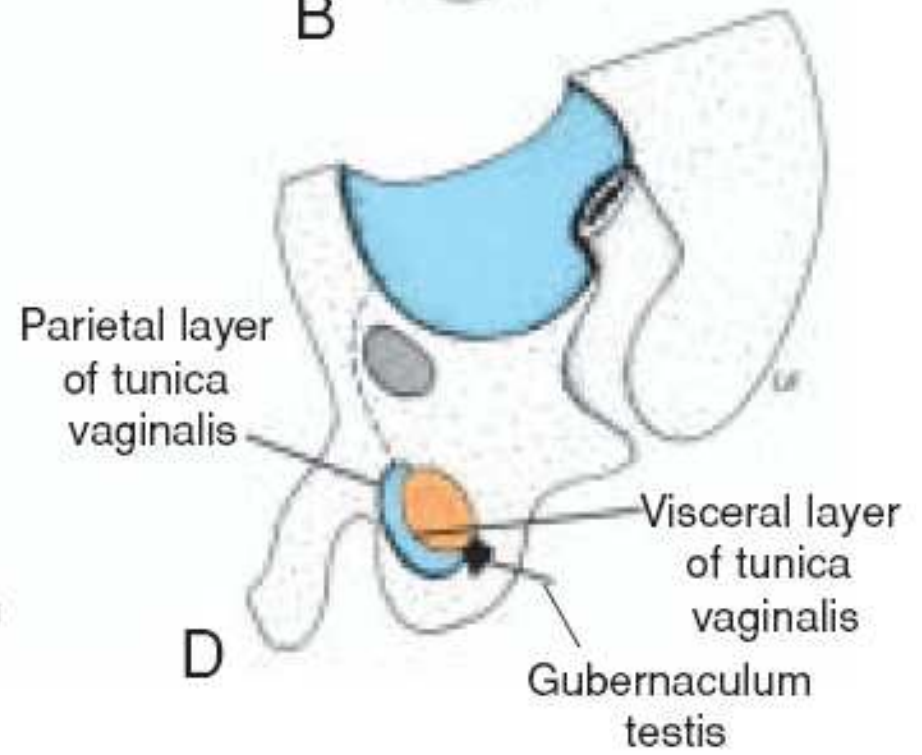
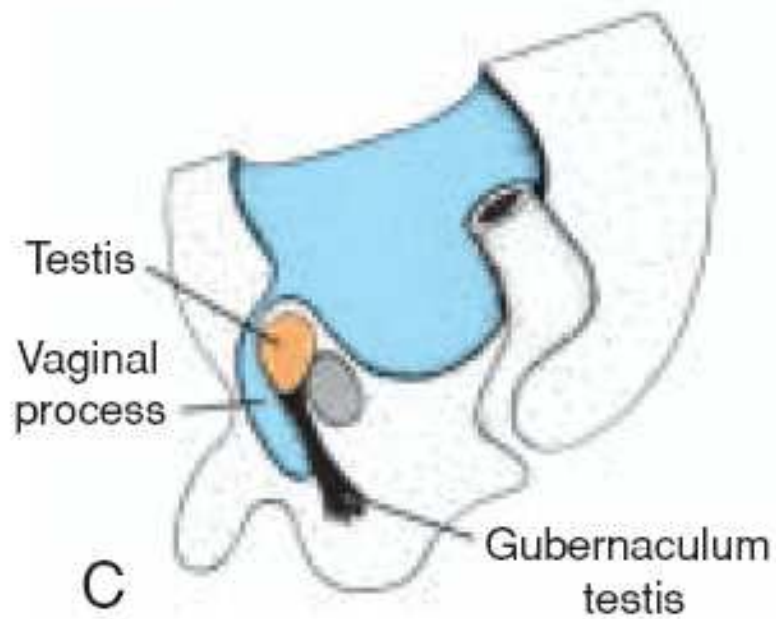
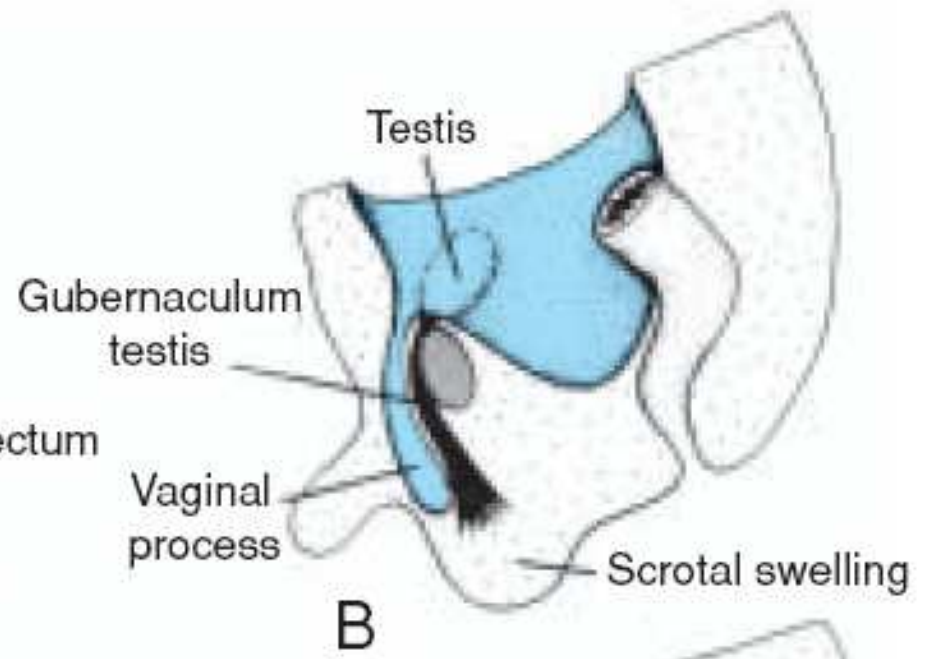
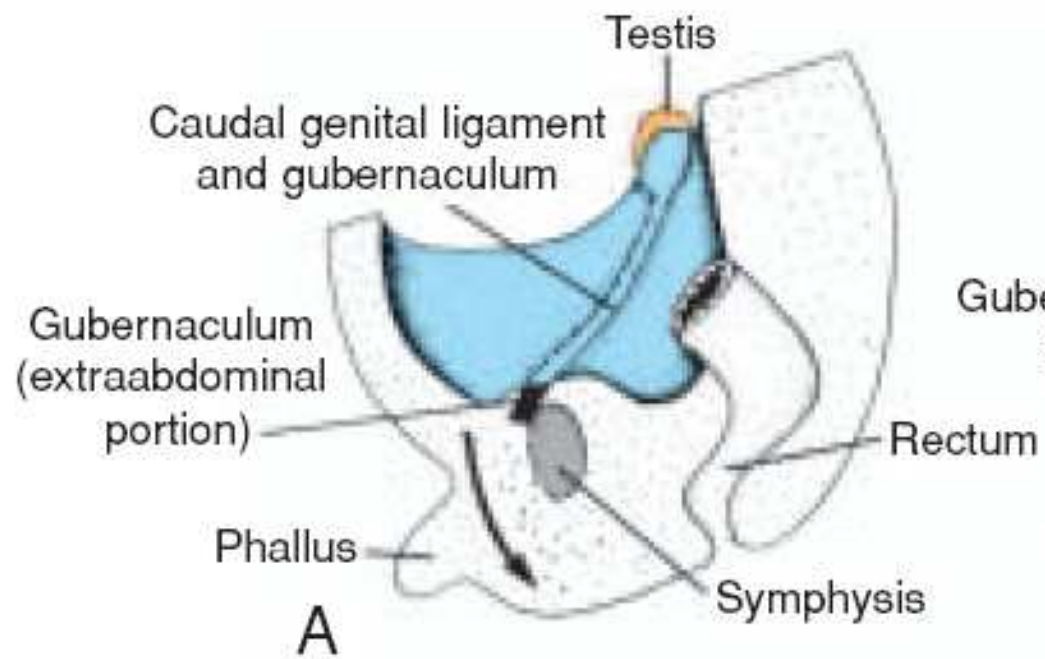
**b- supporting cells (mesodermal): gives Sertoli cells.
They produce mullerian- inhibiting factor (MIF) which suppresses the development of the paramesonephric ducts.**

- The interstitial cells of Leydig develop from the mesoderm located between the cords. They begin to produce testosterone during the 8th week which induces masculine differentiation of the mesonephric ducts and external genitalia.**
- The cords remain solid until puberty, then they become canalized to form the seminiferous tubules which together with the rete testis establish communication with the mesonephric tubules that form the vasa efferentia.**



Descent of the testis:

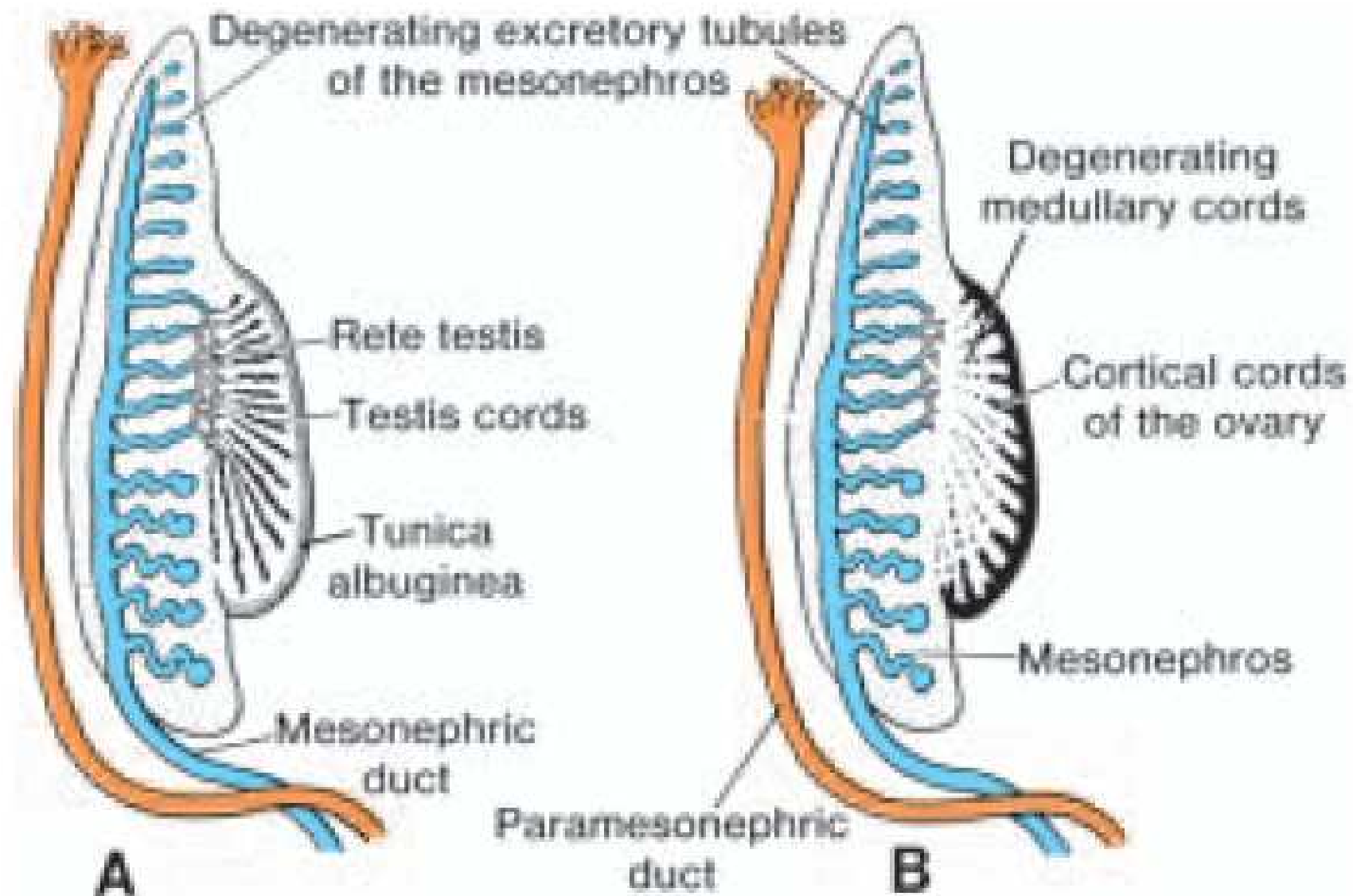
- **The testis develops on the posterior abdominal wall opposite the 1st lumbar vertebra, later it descends to the scrotum pulling after it the testicular artery.**
- **The testis and the mesonephros are attached to the posterior abdominal wall by the urogenital mesentery. Caudal to the testis, it becomes fibromuscular and forms the gubernaculum testis.**
- **In the inguinal region, the gubernaculum passes obliquely through the developing anterior abdominal wall to reach the scrotum. It guides the testis during its descent.**
- **In the 3rd month it reaches the deep inguinal ring, then it migrates through the inguinal canal by the 7th month and reaches the scrotum by the 8th month.**

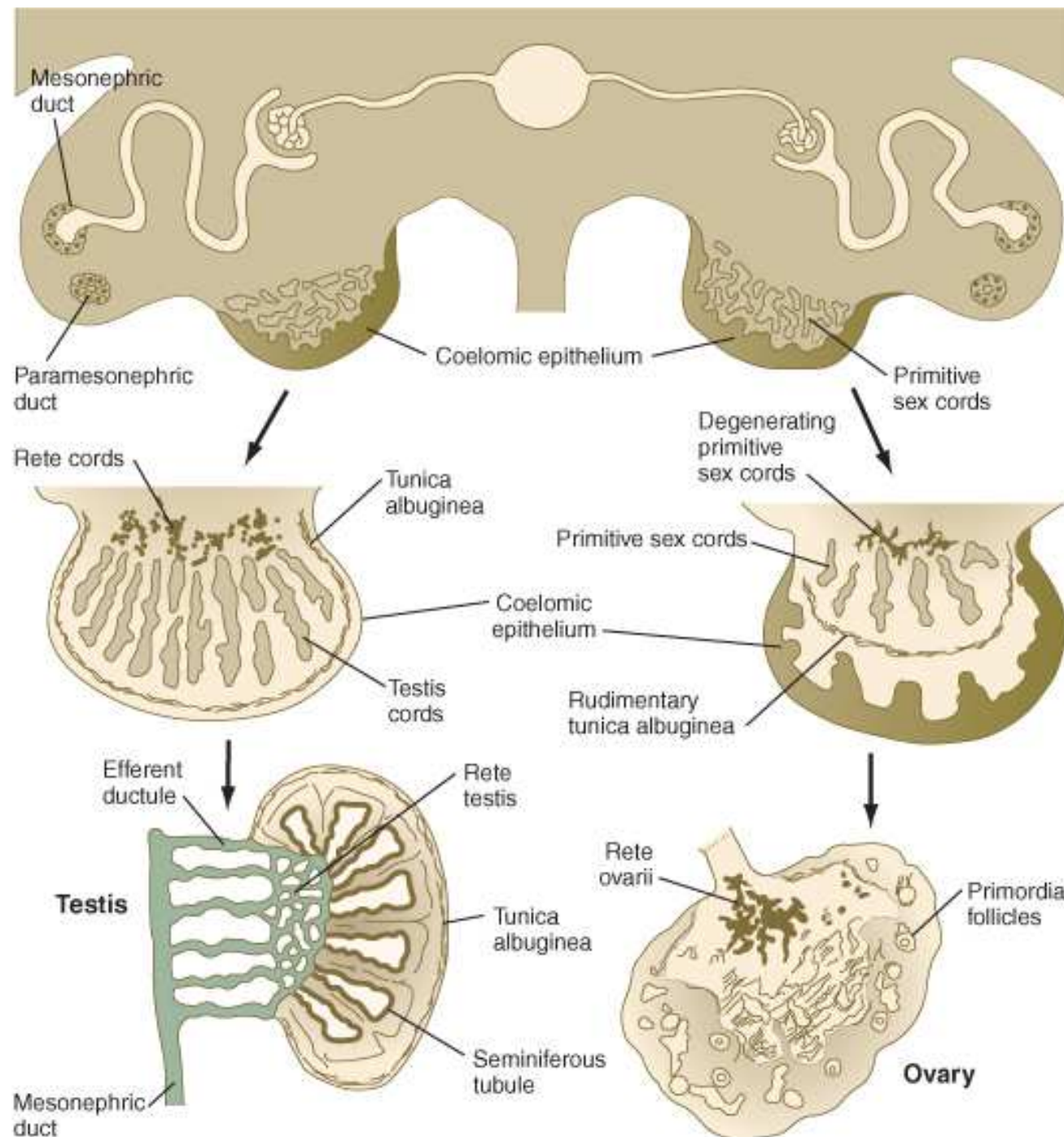


- Descent is caused by:
 - 1- gonadotrophins and androgens.
 - 2- increased intra-abdominal pressure by the growing viscera.
 - 3- shortening of the gubernaculum.
- A pouch of the coelomic cavity (the processus vaginalis) on each side of the midline penetrates the anterior abdominal wall passing ventral to the gubernaculum to reach the scrotum. It pushes the layers of the body wall forming the inguinal canal. The testis descends dorsal to and outside it.
 - * its proximal part is obliterated after birth forming vestige of processus vaginalis.
 - * its distal part is invaginated by the testis forming the visceral and parietal layers of tunica vaginalis.

OVARY:

- The primitive sex cords break into irregular cell clusters called 1ry or medullary cords. These clusters disappear and is replaced by a vascular stroma (ovarian medulla).
- The surface epithelium continues proliferation forms the 2ry or cortical cords which remains close to the surface.
- In the 4th month, these cords split into isolated cell clusters, each surrounds one primitive germ cell forming the primordial follicle:
 - 1- the endodermal germ cells form the oogonia which undergo active mitosis so that all oogonia are formed prenatally.
 - 2- the surrounding mesodermal cells form the follicular cells.
- A thin fibrous capsule, the tunica albuginea separates the surface epithelium from the cortex.





Descent of the ovary:

- The ovary reaches the false pelvis in the 3rd month and the true pelvis shortly after birth.
- The genital mesentery persists forming the mesovarium.

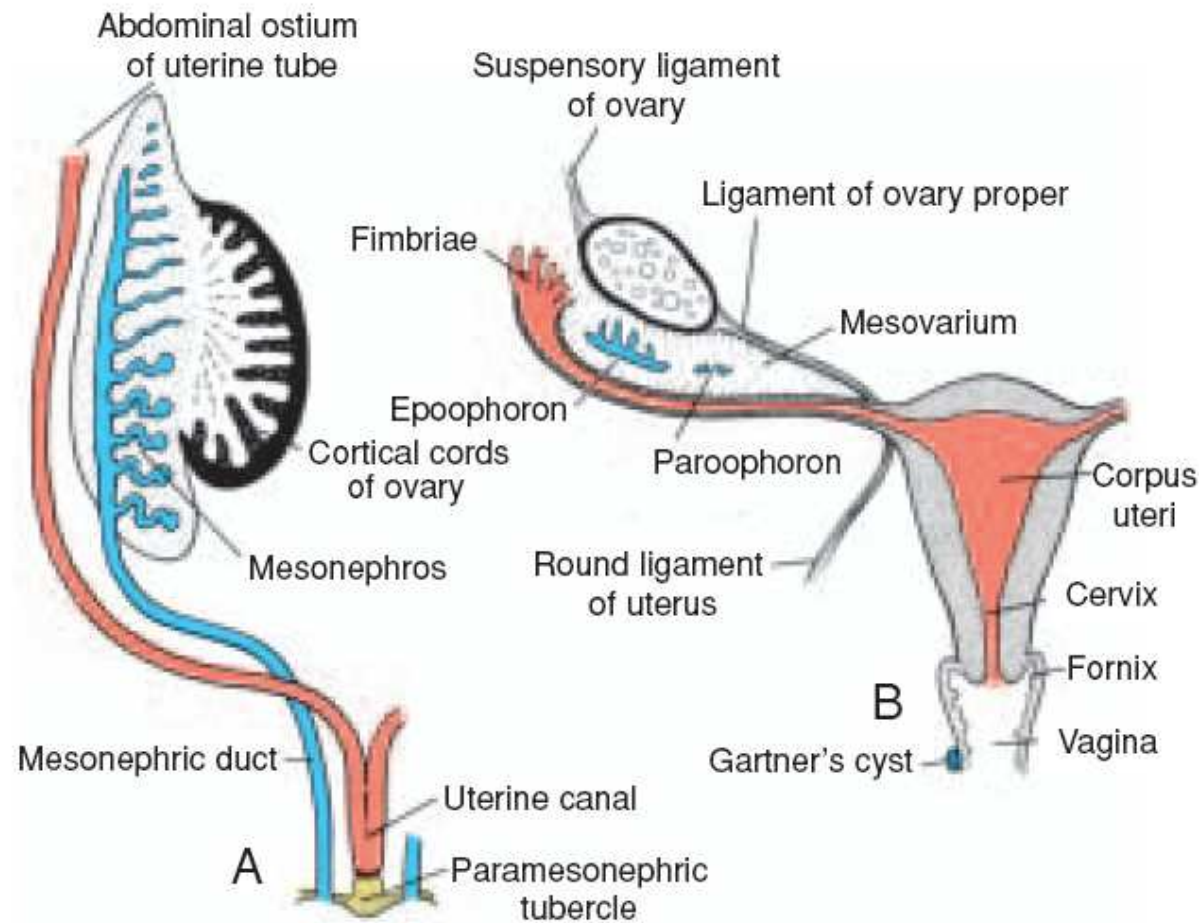
The cranial genital ligament forms the suspensory ligament of the ovary.

The caudal genital ligament becomes divided by the growing uterus into:

1- The ligament of the ovary.

2- The round ligament of the uterus.

- A small processus vaginalis is also formed in females, but it becomes obliterated and disappears after birth.



GENITAL DUCTS

The indifferent stage:

- Both male and female embryos have 2 pairs of genital ducts:

1- The mesonephric (Wolffian) ducts: they play an important role in the development of the male genital system.

- The mesonephric tubules open in them.

- Distally, they drain into the ventral part of the cloaca (urogenital sinus).

2- The paramesonephric (Mullerian) ducts: they play an important role in the development of the female genital system.

- They develop lateral to the mesonephric ducts.
- A longitudinal groove appears in the coelomic epithelium lateral to the mesonephros. The edges of the groove approach each other and fuse to form the paramesonephric duct. The funnel-shaped cranial end of the duct opens into the coelomic cavity forming the abdominal ostium.
- The caudal ends of the ducts grow caudally parallel to the mesonephric ducts as solid cords which later canalize.
- When they reach the pelvic region they turn medially crossing ventral to the mesonephric ducts until they approach each other in the median plane and fuse to form the uterovaginal canal.
- This canal grows caudally and its end projects into the dorsal wall of the urogenital sinus producing an elevation called the sinus (Mullerian) tubercle.

Fate in the male:

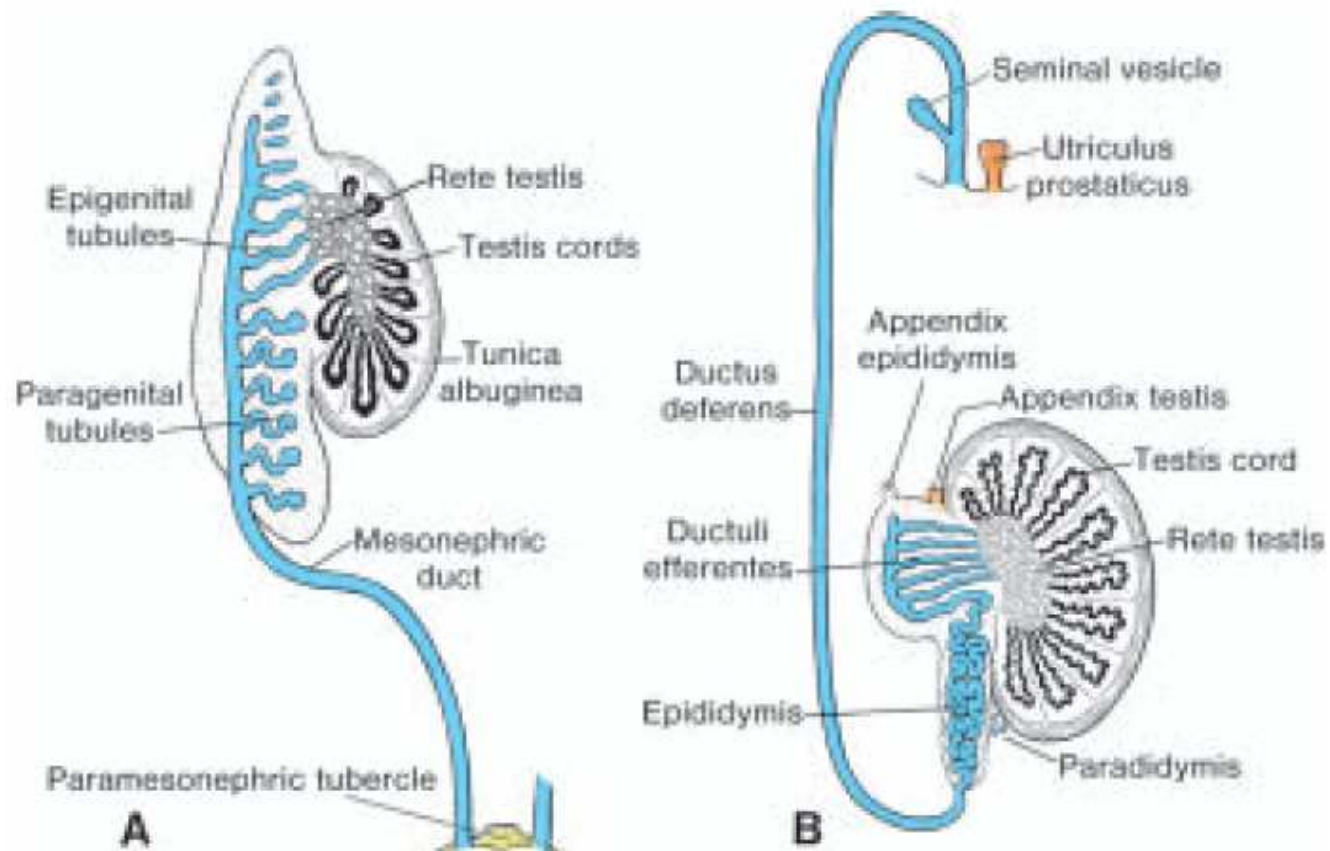
- The fetal testis produce 2 factors:

- 1- Mullerian inhibiting factor (MIF): secreted by sertoli cells to suppress development of paramesonephric ducts.**
- 2- Testosterone: secreted by the interstitial cells to stimulate the mesonephric ducts to form male genital ducts.**

The mesonephric (Wolffian) system: gives the following:

The mesonephric tubules:

- 1- the epigenital tubules: establish contacts with the rete testis and form the efferent ductule and head of epididymis.**
- 2- the paragenital tubules: give the paradidymis.**

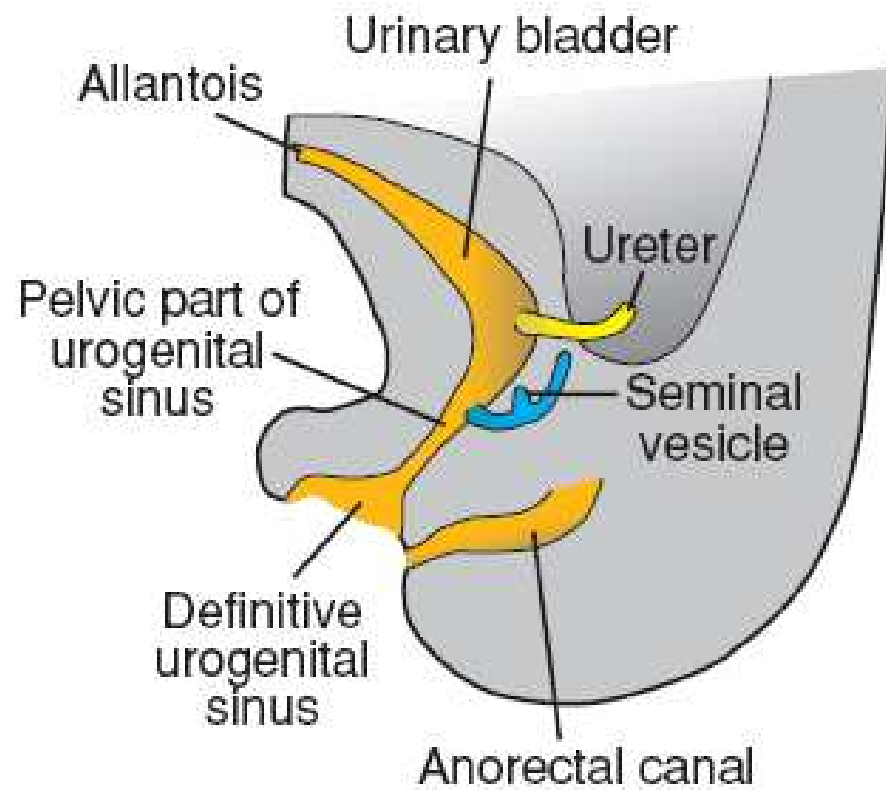


The mesonephric duct:

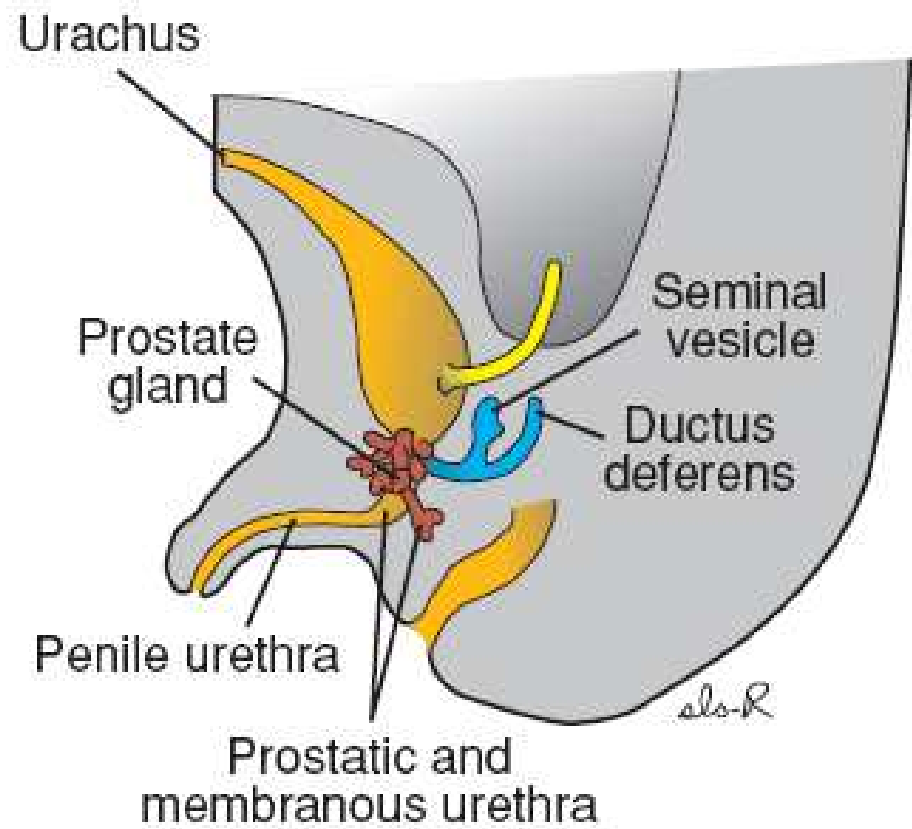
- 1- Its upper blind end: gives the appendix of epididymis.**
- 2- The rest of the duct: gives**
 - a- the body and tail of epididymis.**
 - b- the vas deferens.**
 - c- the seminal vesicles.**
 - d- the ejaculatory ducts.**
 - e- the ureteric bud, the trigone of urinary bladder and part of prostatic urethra.**

The paramesonephric (Mullerian) system:

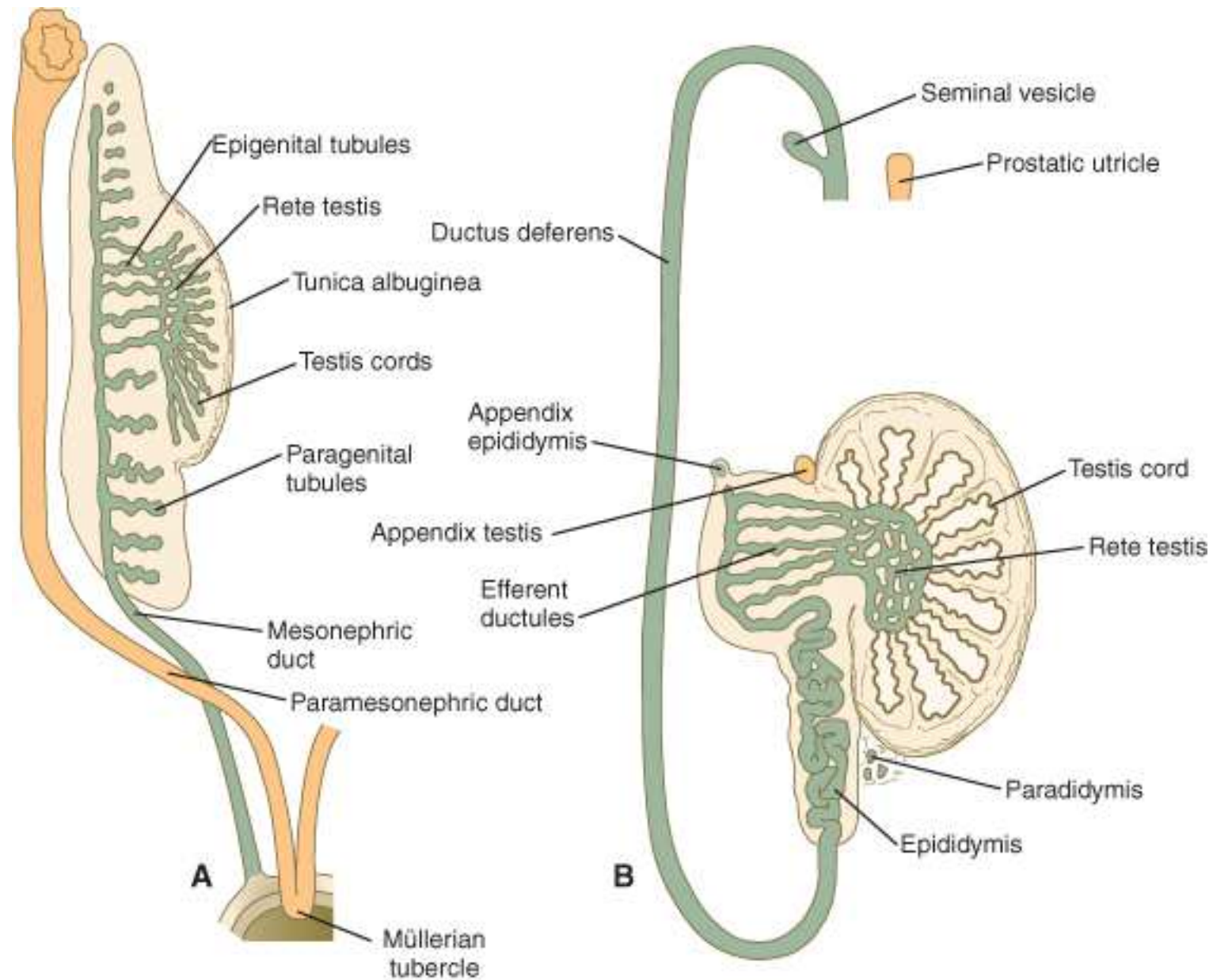
- It degenerates except:**
 - 1- its cranial end gives the appendix of testis.**
 - 2- its caudal end gives the prostatic utricle.**
- the Mullerian tubercle gives the seminal colliculus.**



A



B



Fate in the female:

- In female, the mesonephric ducts regress due to lack of testosterone, while the paramesonephric ducts develop due to absence of the MIF.

The mesonephric (Wolffian system):

1- the mesonephric tubules:

a- upper tubules degenerate.

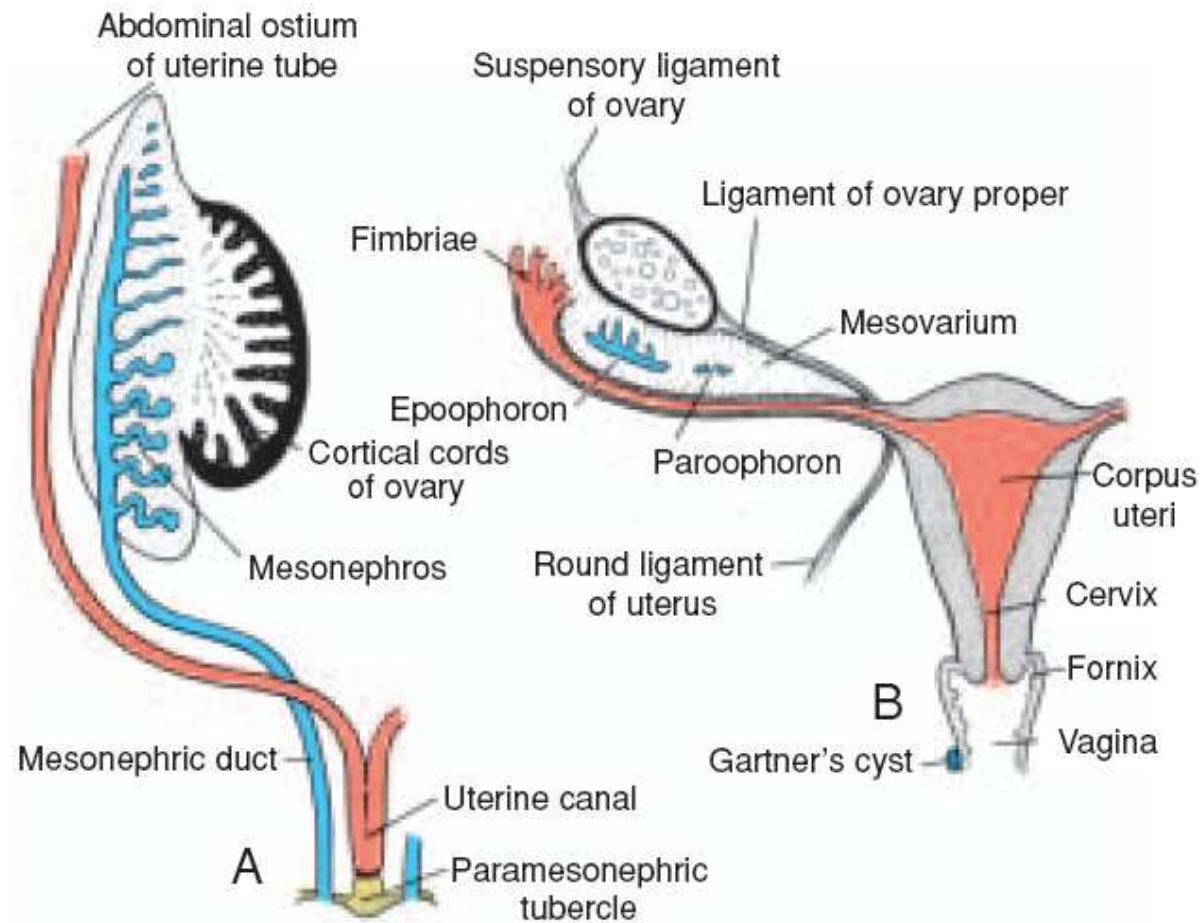
b- middle tubules give the epoophoron (above the ovary).

c- lower tubules give the paroophoron (medial to the ovary).

2- the mesonephric duct:

- the caudalmost part gives the ureteric bud and trigone.

- the rest of the duct gives Gartner's duct (lateral to uterus and vagina).

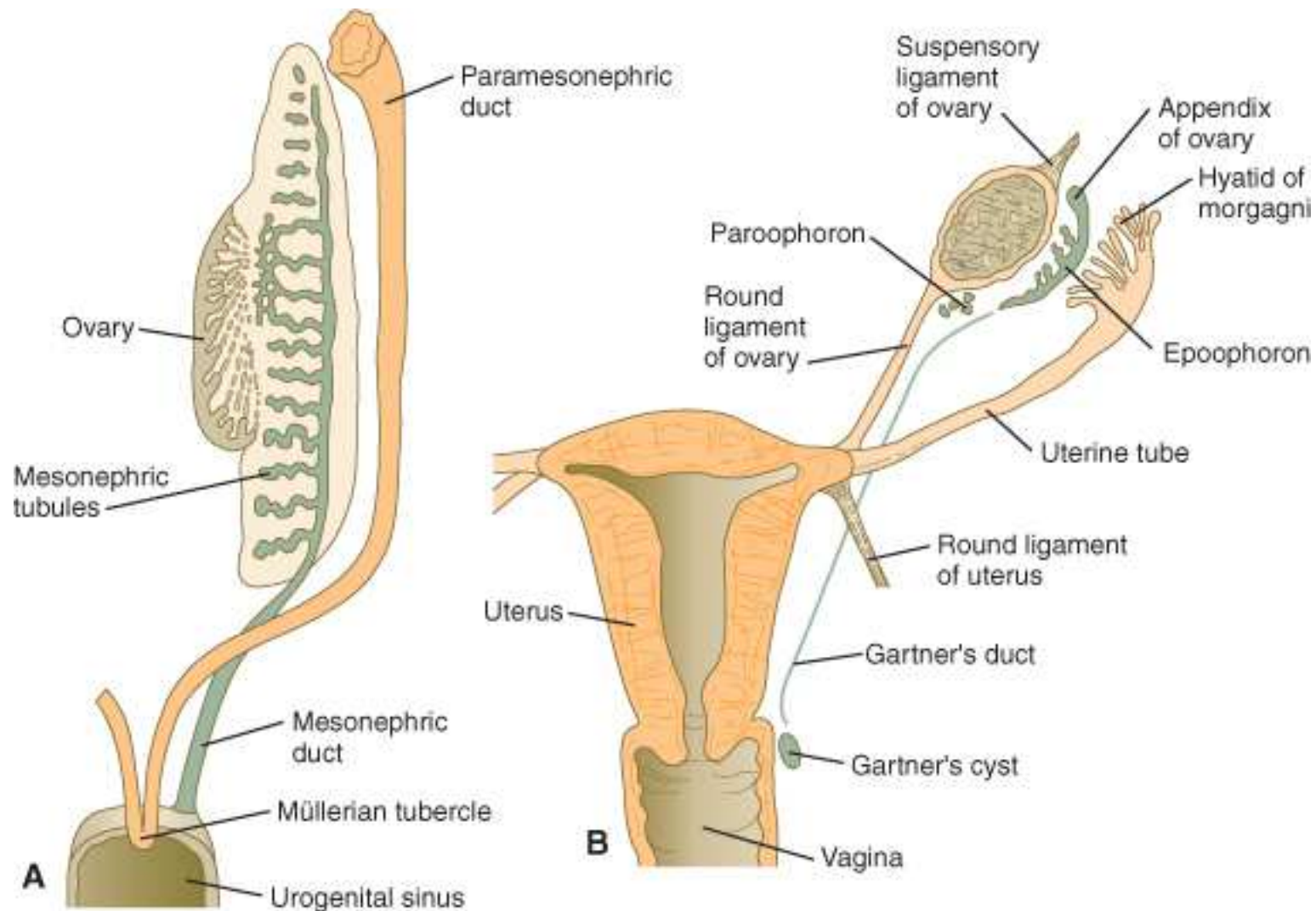


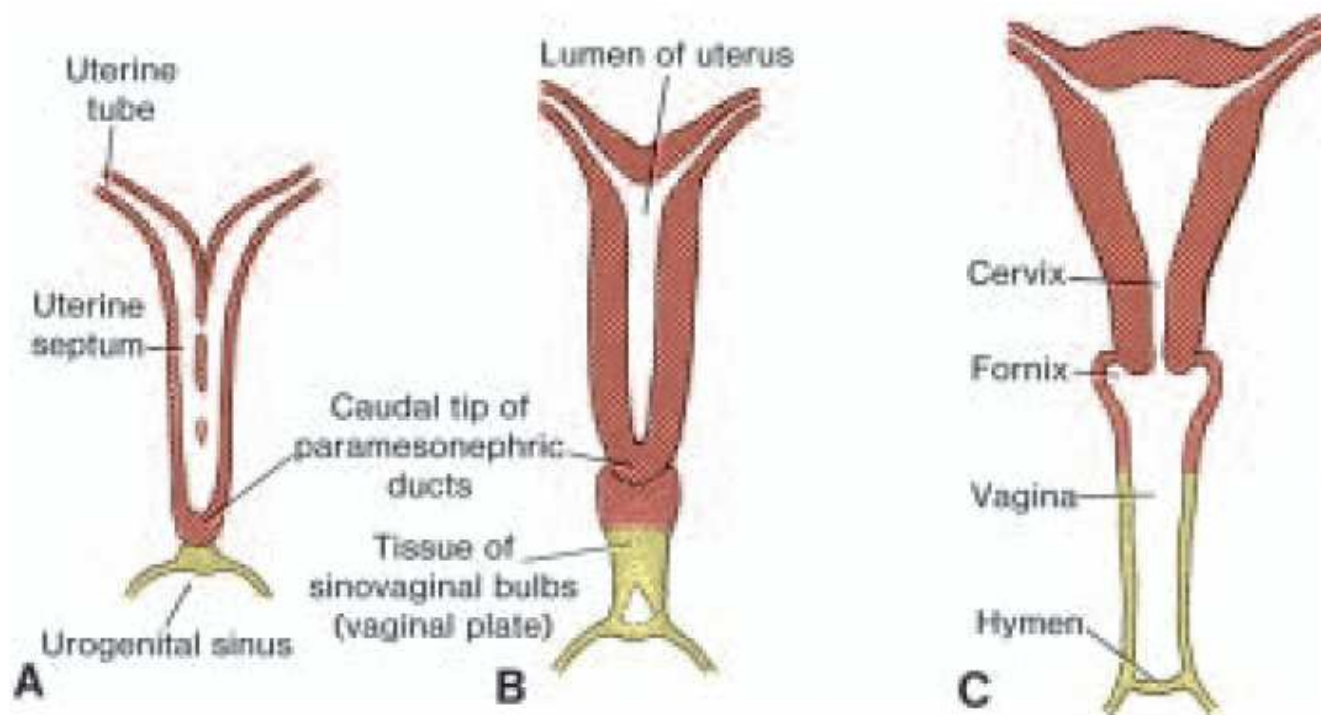
The paramesonephric (Mullerian) system:

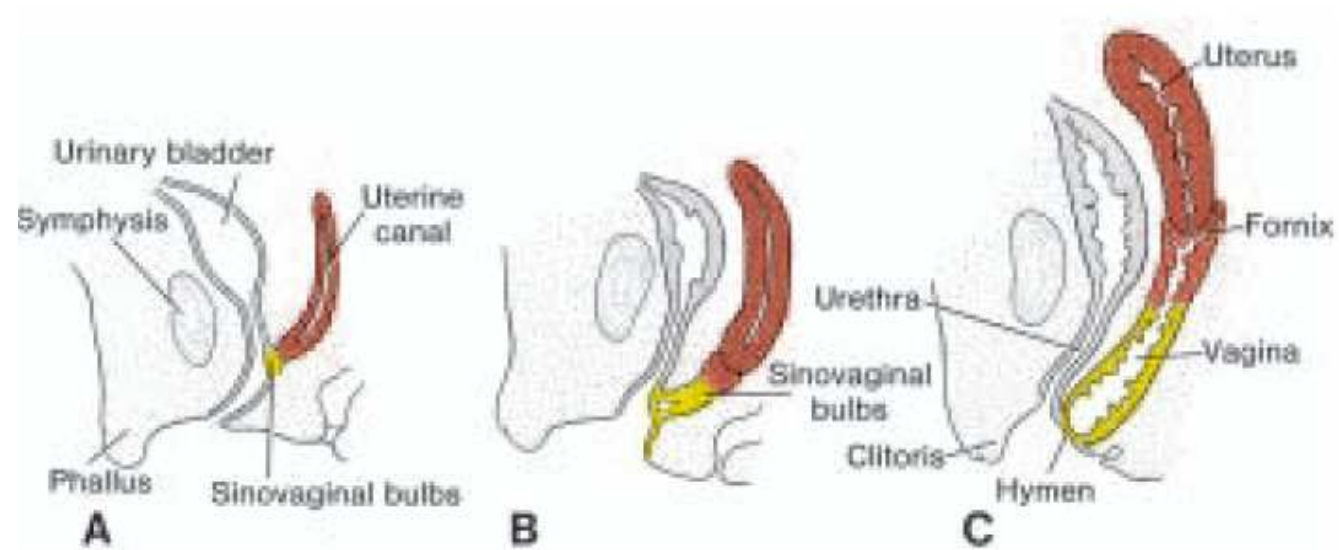
- The paramesonephric ducts give the following:
 - 1- The cranial, unfused parts give the uterine (Fallopian) tubes.
 - 2- The caudal fused parts form the uterovaginal canal which gives rise to the uterus and upper 1/3 of the vagina.

VAGINA

- At the site of mullerian tubercle, two solid evaginations grow out from the pelvic part of the urogenital sinus.
- These evaginations (sinovaginal bulbs) fuse and form a solid vaginal plate which grows cranially and later canalize.
- A thin plate, the hymen, separates the lumen of the vagina from the urogenital sinus which ruptures in its middle during perinatal life.







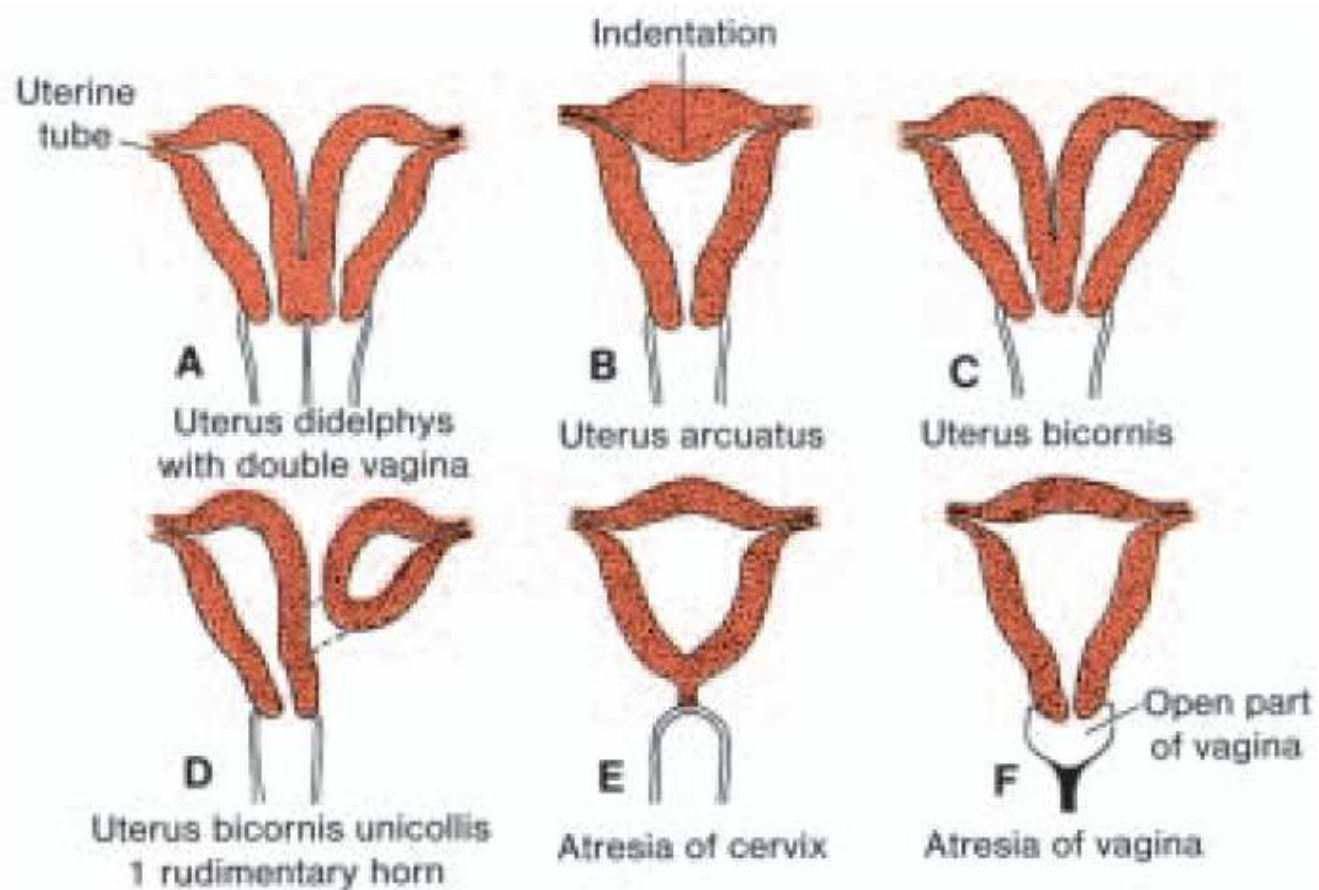
CONGENITAL ANOMALIES OF THE GENITAL SYSTEM:

Anomalies of the testis:

- 1- Undescended testis (cryptorchidism): may be caused by decreased testosterone.**
- 2- Congenital inguinal hernia: due to patent processus vaginalis.**

Anomalies of the paramesonephric duct:

- 1- Failure of fusion: leads to**
 - a- Uterus didelphys: the uterus and vagina are double.**
 - b- Uterus arcuatus: the fundus is slightly indented.**
 - c- Uterus septatus: the uterus has a septum.**
 - d- Uterus bicornis: the uterus has 2 horns and common vagina.**
- 2- Failure of canalization: causing atresia of cervix or vagina or imperforate hymen.**



FORMATION OF THE DIAPHRAGM

The diaphragm divides the body cavity into the thoracic and peritoneal cavities. It develops from 4 components:

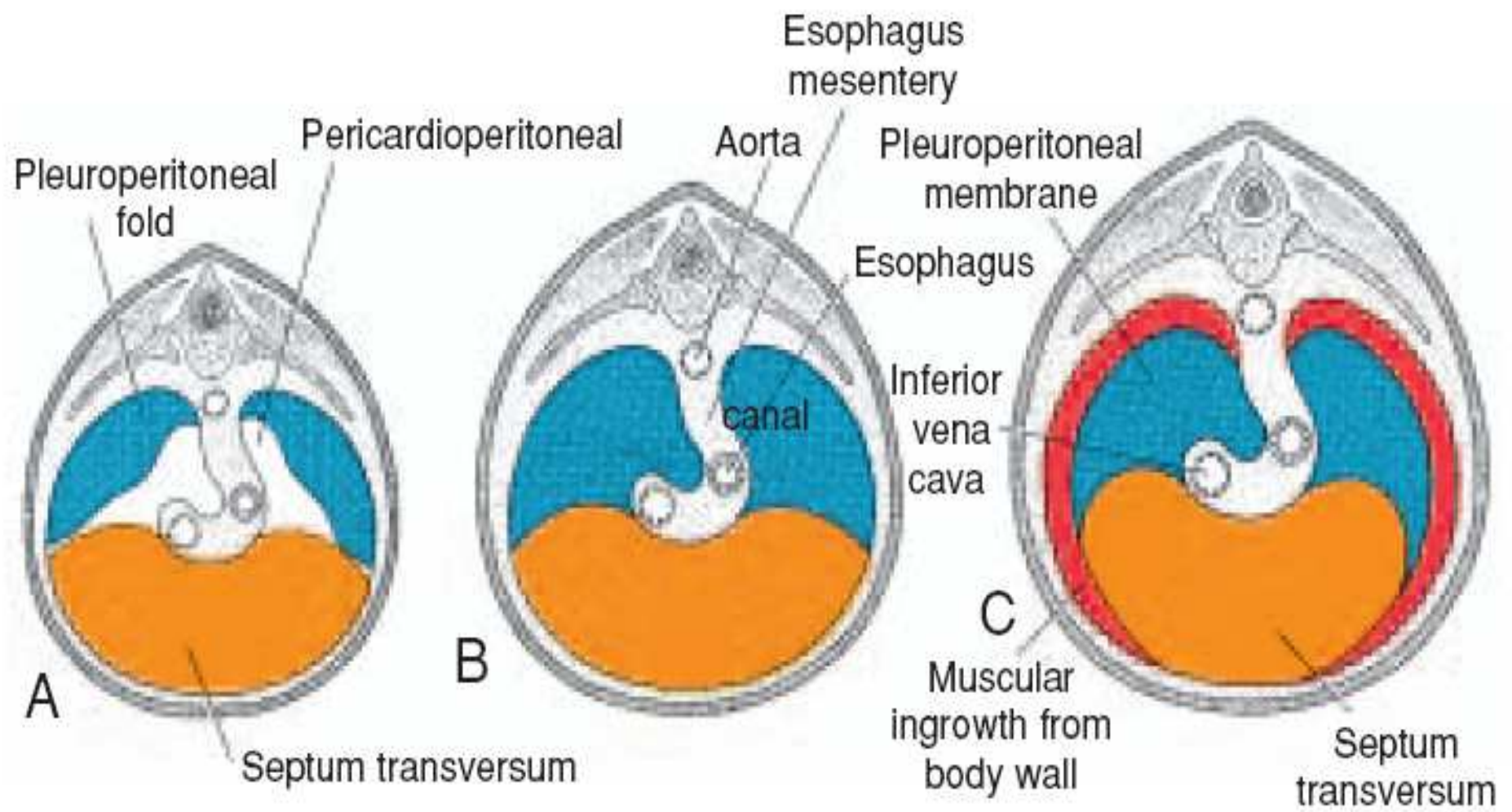
1- Septum transversum (central tendon).

2- Pleuroperitoneal membranes.

3- dorsal mesentry of the esophagus.

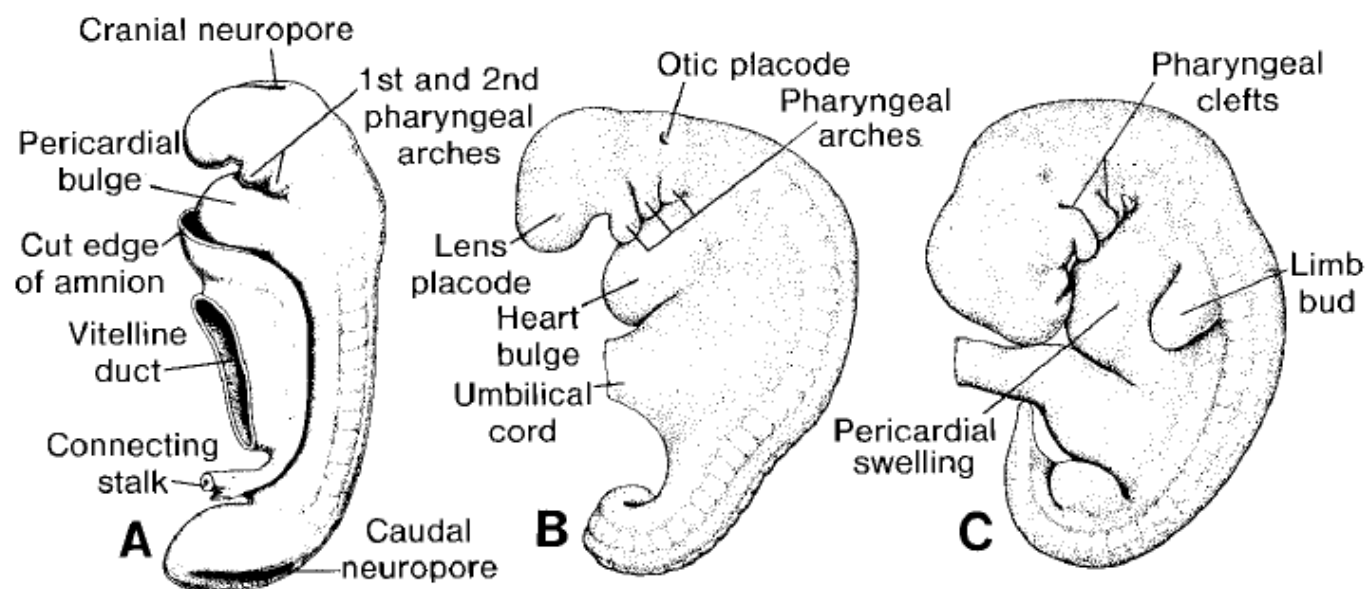
4- Muscular components of the body wall.

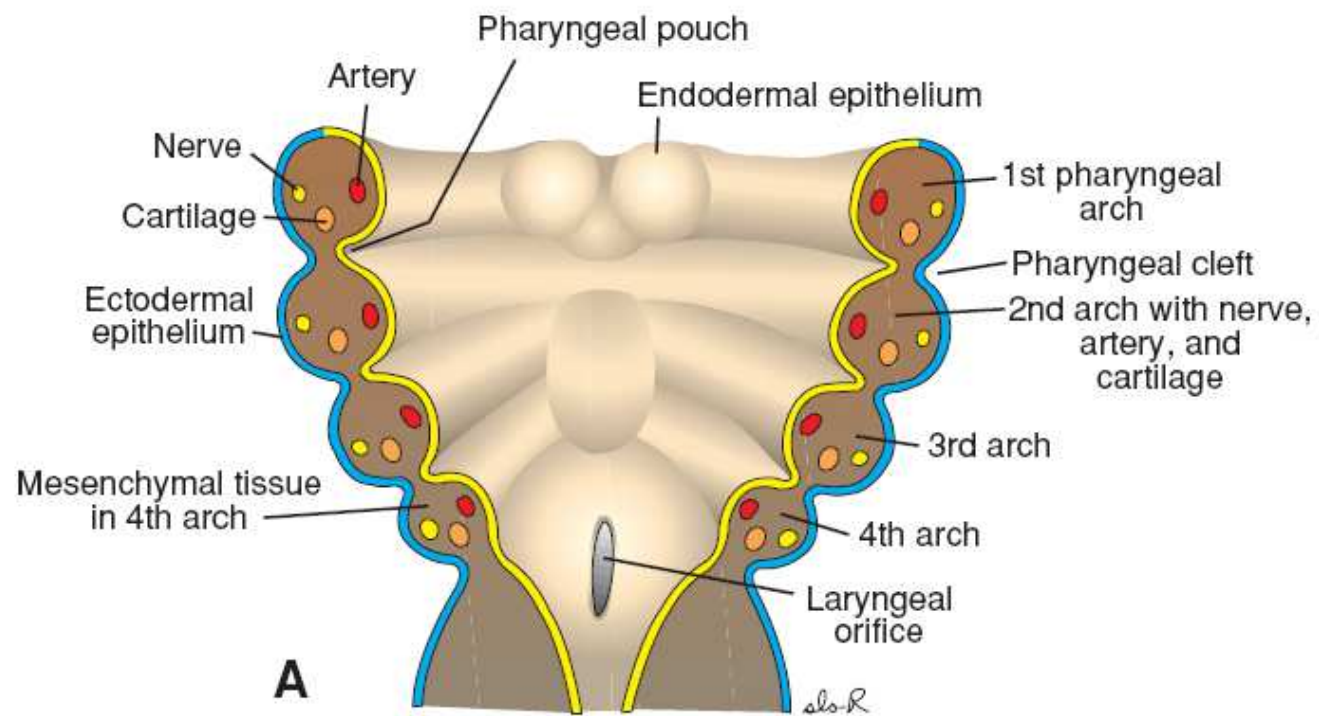
- Congenital diaphragmatic hernia is caused by failure of the pleuroperitoneal membranes to close the pericardioperitoneal canal.



PHARYNGEAL (BRANCHIAL) APPARATUS

- The pharyngeal arches are 6 curved cylindrical mesodermal thickenings on each side of the primitive pharynx.
- Each arch consists of:
 - a- an outer ectodermal covering.
 - b- an inner endodermal lining.
 - c- a mesodermal core inbetween.
- They are separated from each others externally by grooves called pharyngeal clefts, and internally by grooves called pharyngeal pouches.
- The mesodermal component of each arch differentiates into the following components:
 - 1- Skeletal element: (arch cartilage) which differentiates into certain cartilages, ligaments and bones of head and neck.
 - 2- Muscular element: differentiates into certain muscles..

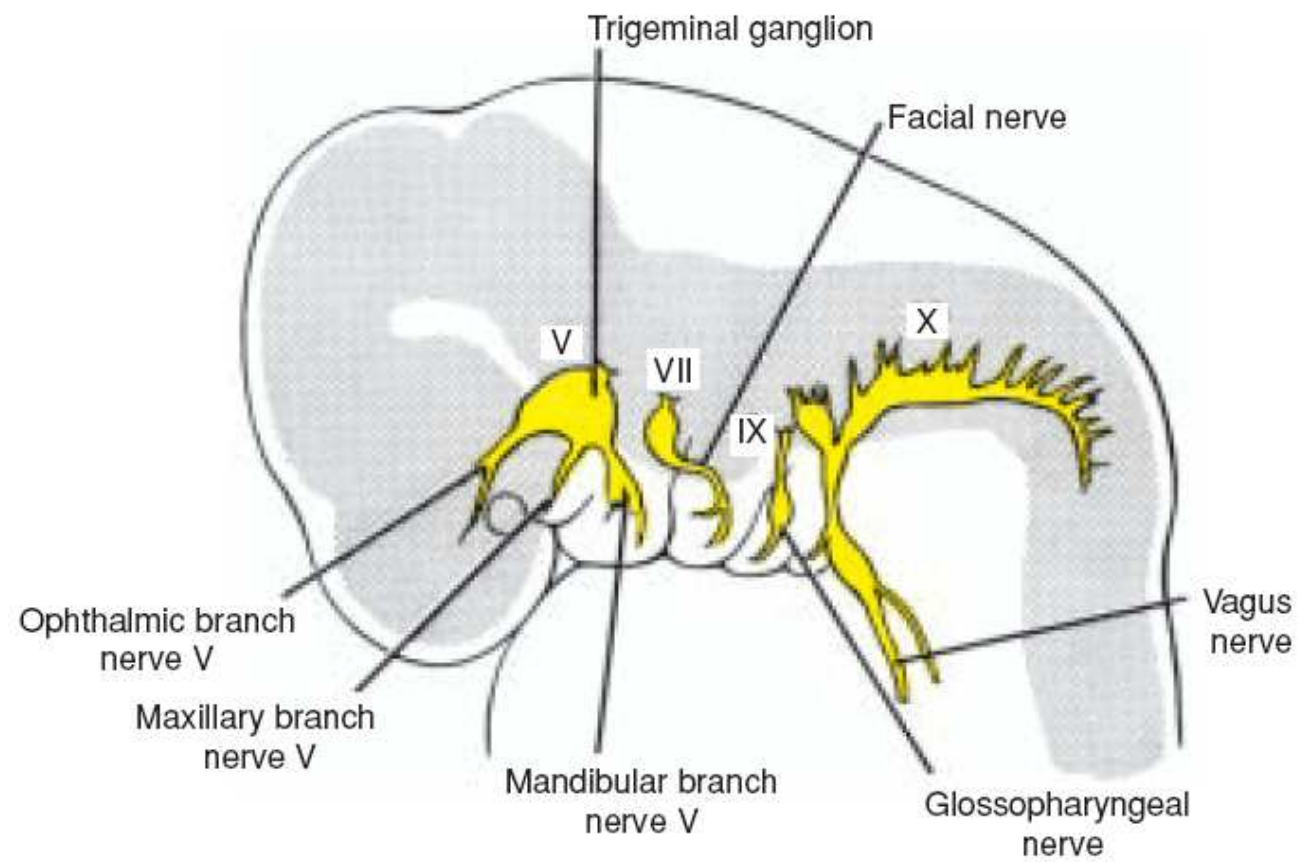


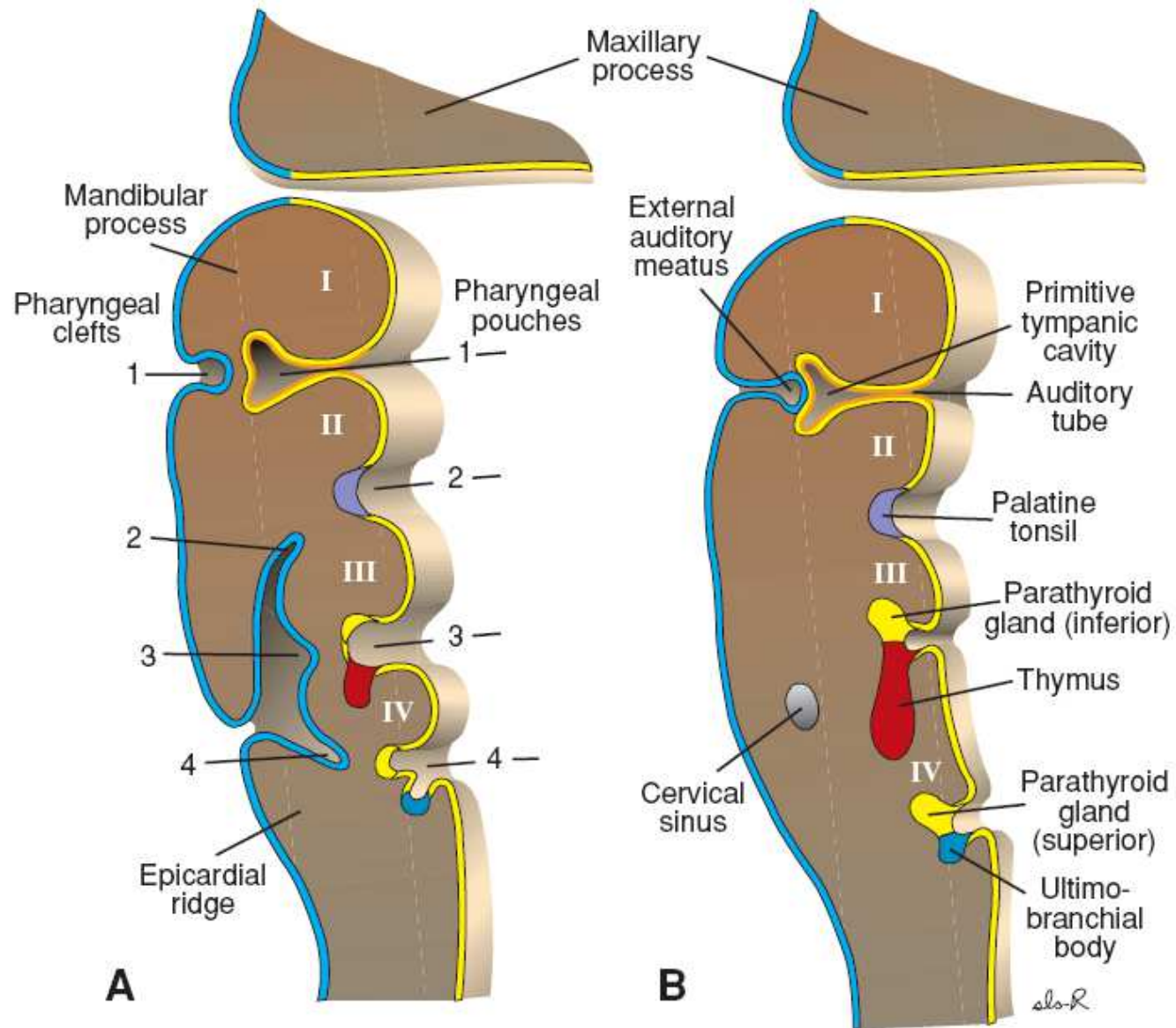


- 3- Vascular element: an aortic arch artery develops in each arch and becomes connected with the aortic sac and dorsal aorta.**
- 4- Nervous element: represented by a mixed cranial nerve which arises from the hindbrain and grows into the arch.**

Derivatives of pharyngeal clefts:

- 1- 1st cleft: its dorsal part forms the external auditory meatus and outer layer of ear drum.**
- 2- 2nd, 3rd and 4th clefts: the mesoderm of the 2nd arch grows downward pushing the ectoderm till it fuses with the ectoderm at the root of the neck covering the 2nd, 3rd, and 4th clefts forming a cavity called the cervical sinus which becomes obliterated and the clefts become barred.**





Derivatives of pharyngeal pouches:

1- 1st pouch:

- ventral part: obliterated by the developing tongue.
- dorsal part: forms the tubotympanic recess which gives:
 - a- the pharyngo-tympanic tube.
 - b- the middle ear cavity.
 - c- the inner layer of ear drum.

2- 2nd pouch:

- ventral part: obliterated.
- dorsal part: gives primordium of palatine tonsils.

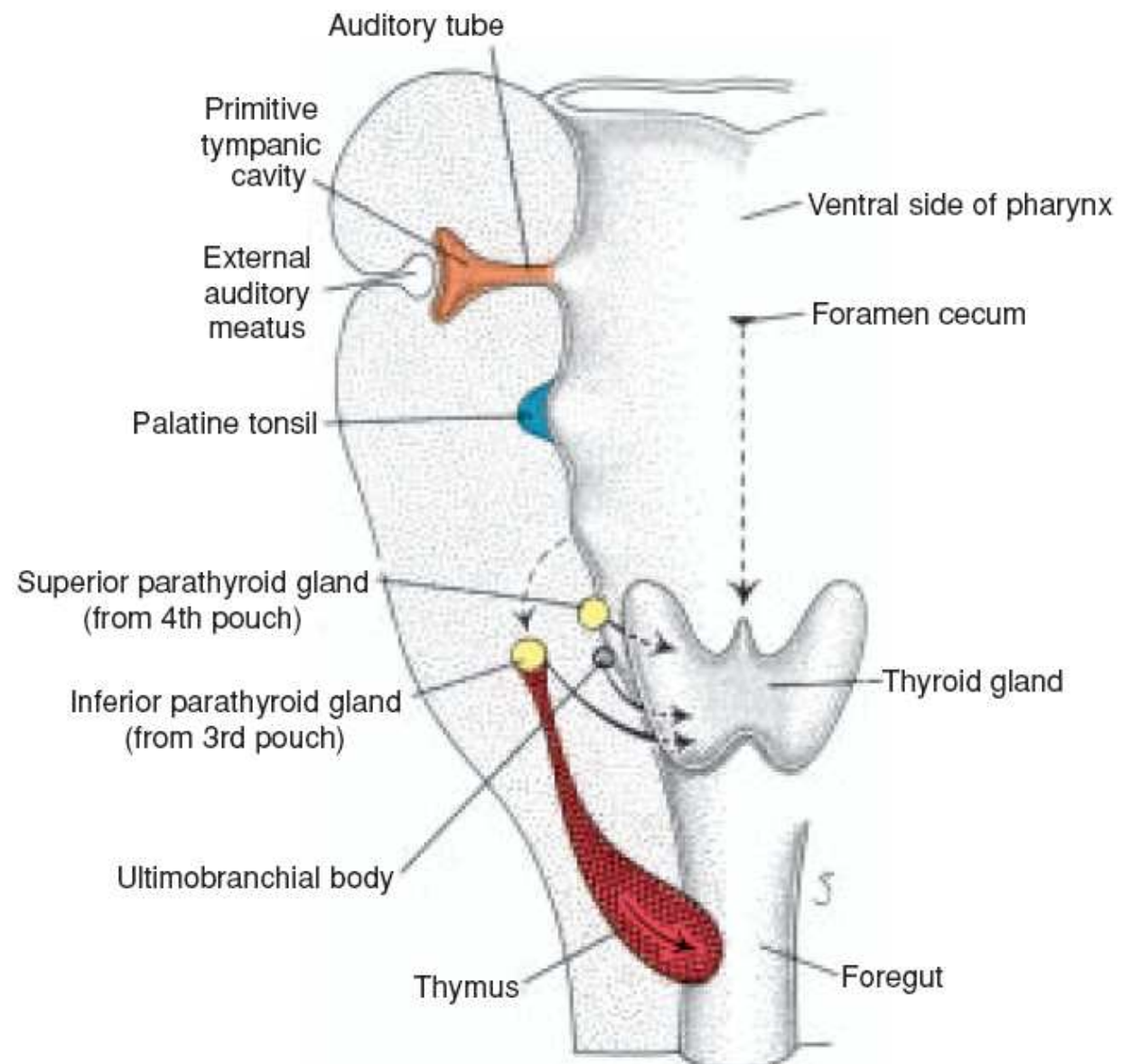
3- 3rd pouch:

- ventral part: form the thymus gland.
- dorsal part: forms the inferior parathyroid glands.

4- 4th pouch:

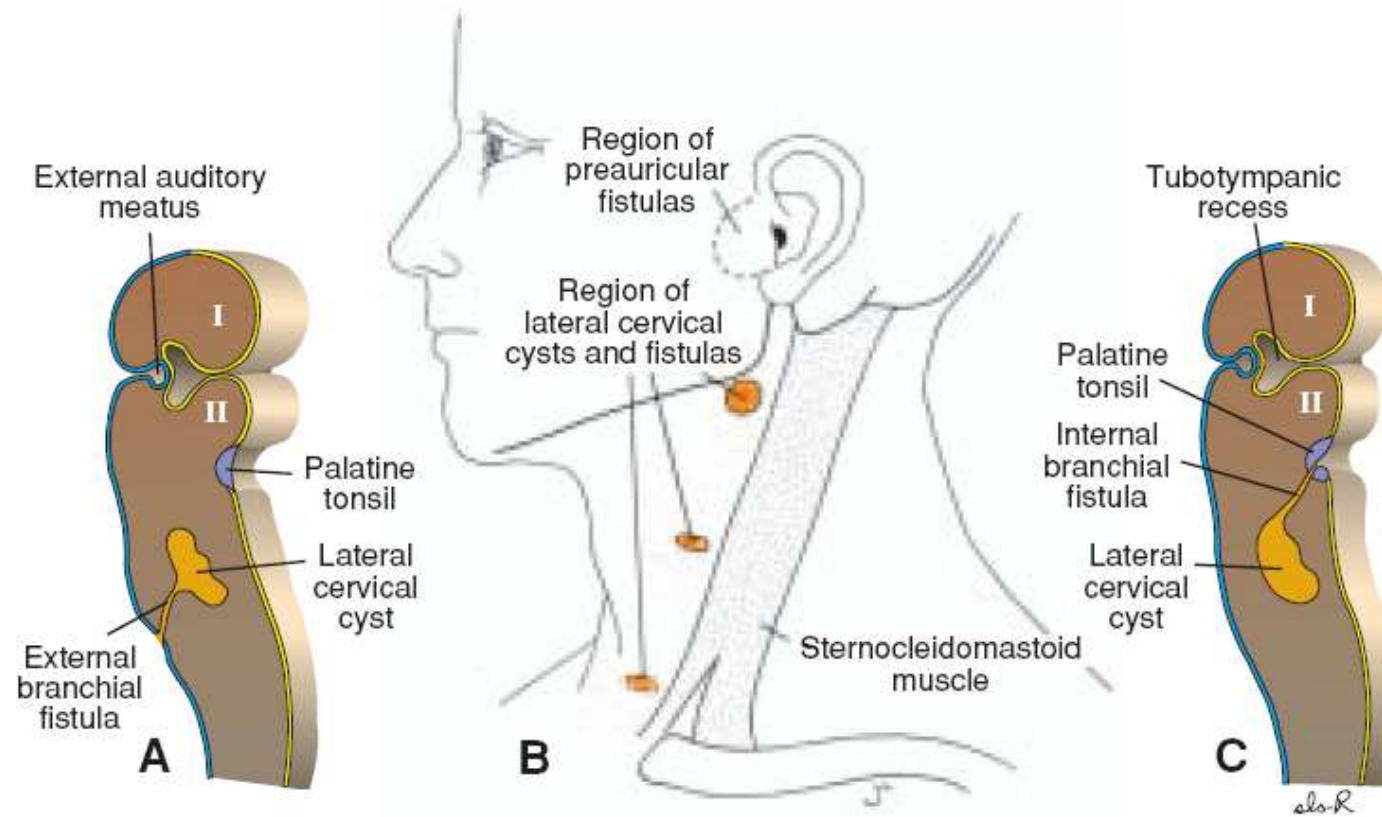
- ventral part: gives small contribution to the thyroid and thymus glands.
- dorsal part: gives the superior parathyroid glands.

5- 5th pouch: gives the ultimobranchial body.



Congenital anomalies:

- 1- Ectopic thymus and parathyroid tissue: accessory glands or remnants of tissue may persist along the pathway of their migration.**
- 2- Lateral cervical cyst: due to unobliterated cervical sinus.**
- 3- Branchial fistula: when the 2nd pharyngeal arch fails to grow caudally leaving remnants of the 2nd, 3rd and 4th clefts in contact with the surface by a narrow canal.**



Derivatives of pharyngeal arches:

1- 1st arch:

a- skeletal derivatives:

- It consists of 2 portions:

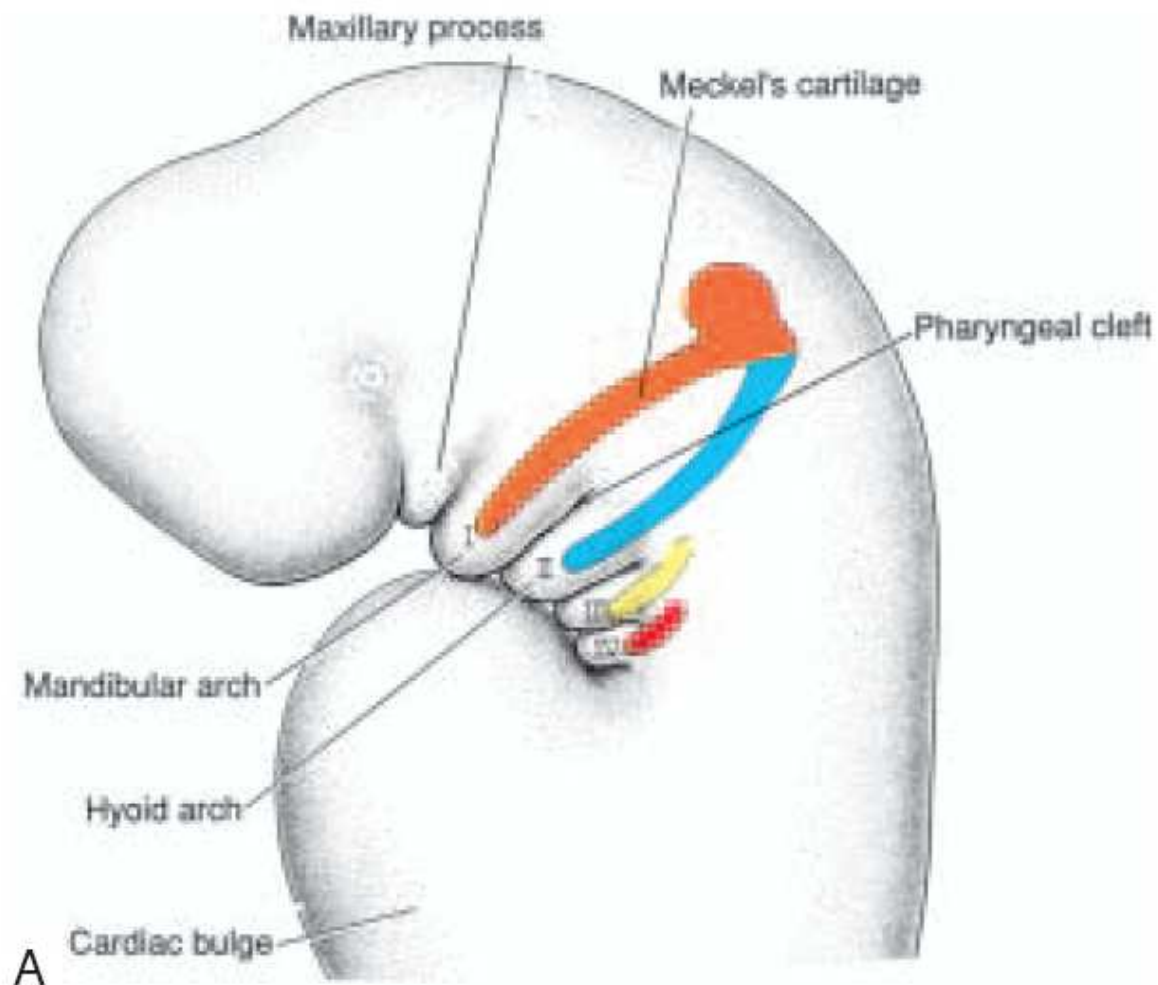
1- Maxillary process: gives rise to premaxilla, maxilla, zygomatic bone and part of temporal bone through membranous ossification.

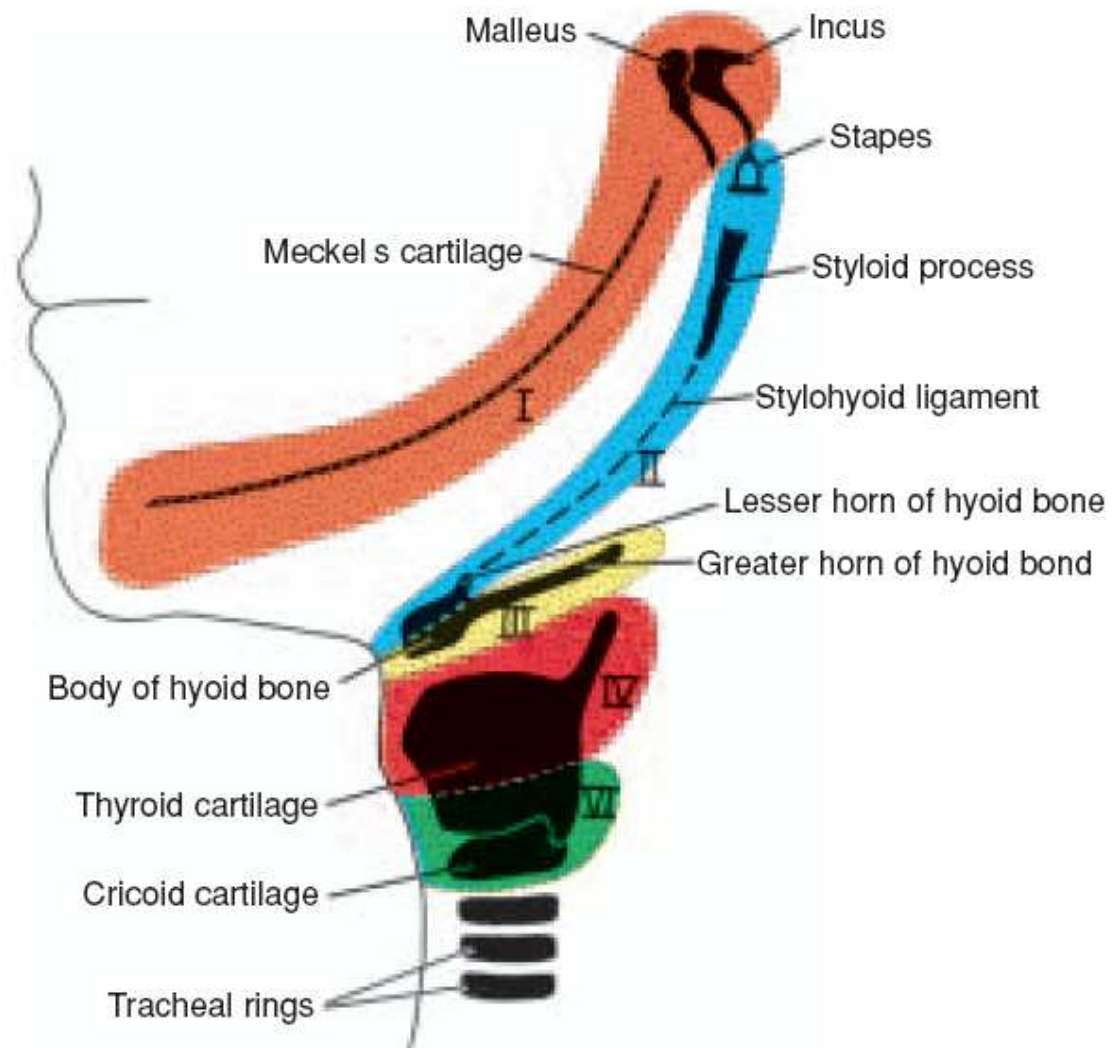
2- Meckel's cartilage, differentiates into:

- dorsally: incus and malleus.
- middle part: sphenomandibular ligament.
- ventrally: the most anterior part of mandible. The rest of mandible develops by membranous ossification around Meckel's cartilage.

b- Muscular derivatives: - 4 muscles of mastication.

- 4 other muscles (mylohyoid, anterior belly of digastric, tensor palati & tensor tympani).





- The nerve of this arch is the trigeminal nerve (maxillary and mandibular divisions).

2- 2nd (hyoid) arch:

a- Skeletal derivatives:

Reichert's cartilage gives rise to (from dorsal to ventral): stapes, styloid process, stylohyoid ligament, lesser horn and upper part of body of hyoid bone.

b- Muscular derivatives:

It gives rise to : stapedius, stylohyoid, posterior belly of digastric, auricular, and muscles of facial expression.

- The nerve of this arch is the facial nerve.

3- 3rd arch:

a- Skeletal derivatives:

The cartilage of this arch forms the lower part of the body and the greater horn of hyoid bone.

b- Muscular derivatives:

Stylopharyngeus muscle.

- The nerve of this arch is the glossopharyngeal nerve.

4- 4th and 6th arches:

a- skeletal derivatives:

Their cartilages fuse to form thyroid, cricoid, arytenoid, corniculate and cuneiform cartilages of the larynx.

b- Muscular derivatives:

- muscles of the 4th arch: cricothyroid, levator palati and constrictors of the pharynx.
- muscles of the 6th arch: intrinsic muscles of the larynx.
- The nerve of 4th arch is the superior laryngeal branch of vagus.
- _ The nerve of the 6th arch is the recurrent laryngeal branch of vagus.

DEVELOPMENT OF THE TONGUE

1- Mucous membrane:

- anterior 2/3: arise from 3 swelling derived from the 1st pharyngeal arch:

- a- Tuberculum impar: a small median elevation.

- b- 2 lingual swellings on either side.

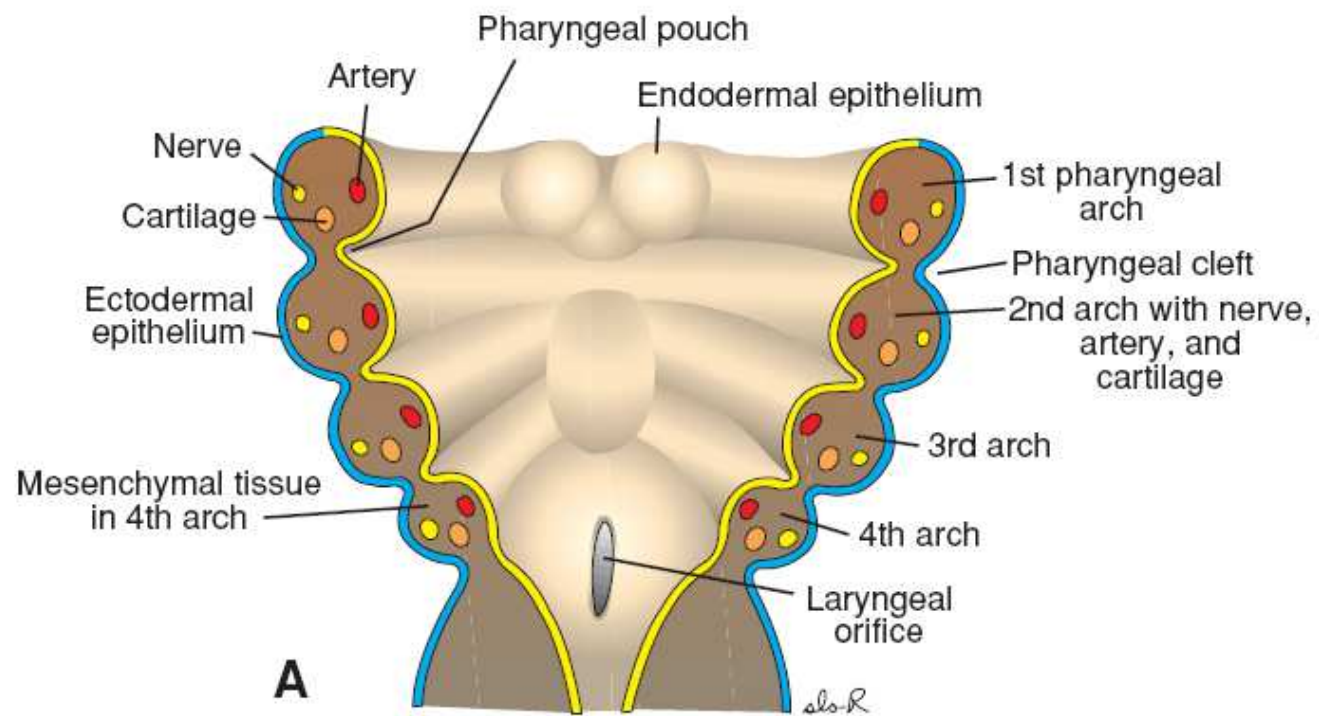
- posterior 1/3 from the endoderm of the 3rd arch:

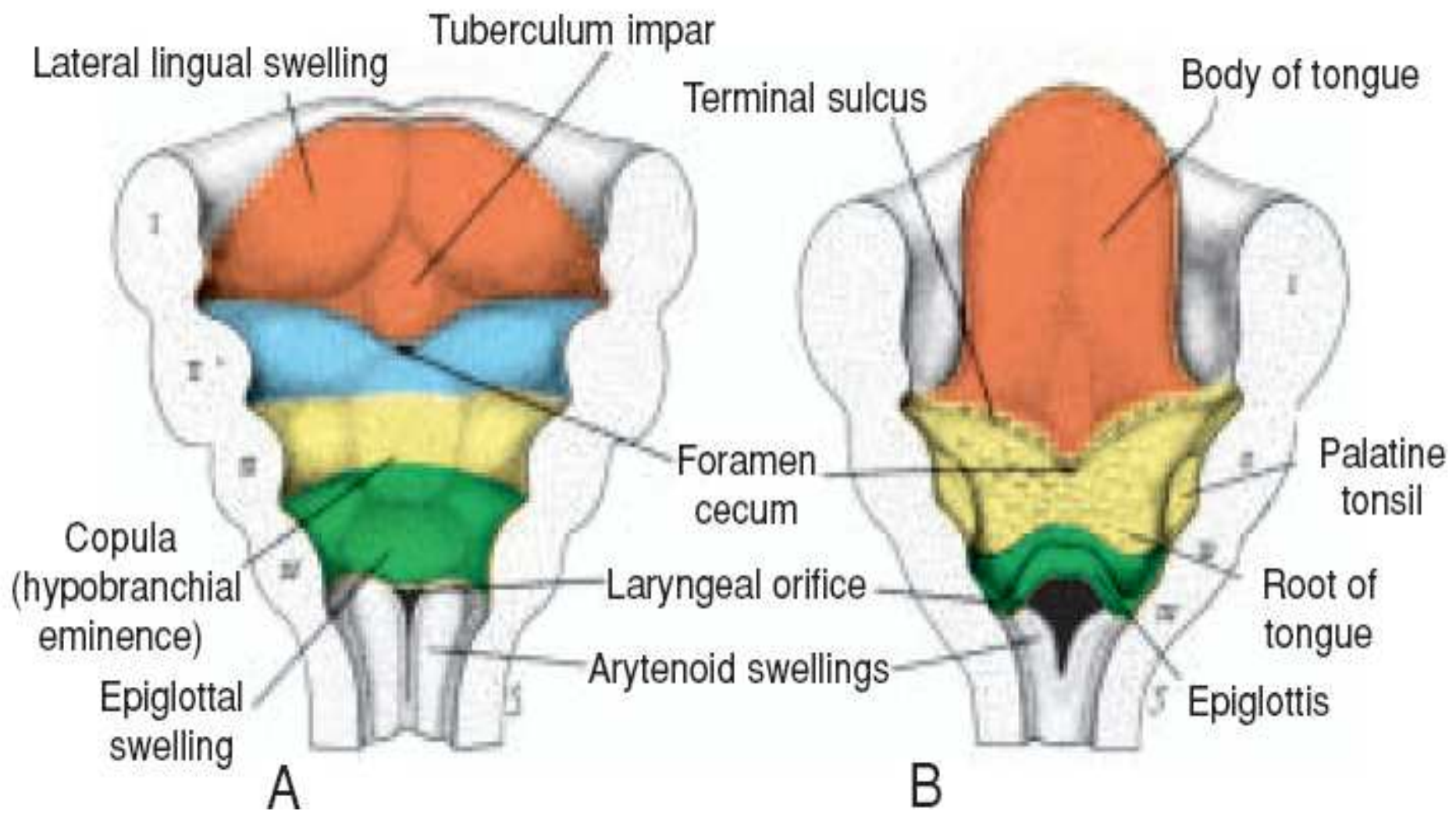
The endoderm of the 2nd, 3rd and 4th arches fuse to form the hypobranchial eminence which is divided into:

- upper part: (mainly from the 3rd arch) grows in a v-shaped manner and forms posterior 1/3 of tongue.

- lower part: (mainly from the 4th arch) forms the epiglottis.

The posterior 1/3 fuses with the anterior 2/3 along the v-shaped sulcus terminalis.





N.B.

- ant. 2/3 is supplied by the mandibular nerve (of 1st arch)
- post. 1/3 is supplied by glossopharyngeal nerve (of 3rd arch).

2- muscles of the tongue:

are derived from occipital myotomes which migrate into the tongue dragging with them their nerve supply (hypoglossal nerve).

Congenital anomalies:

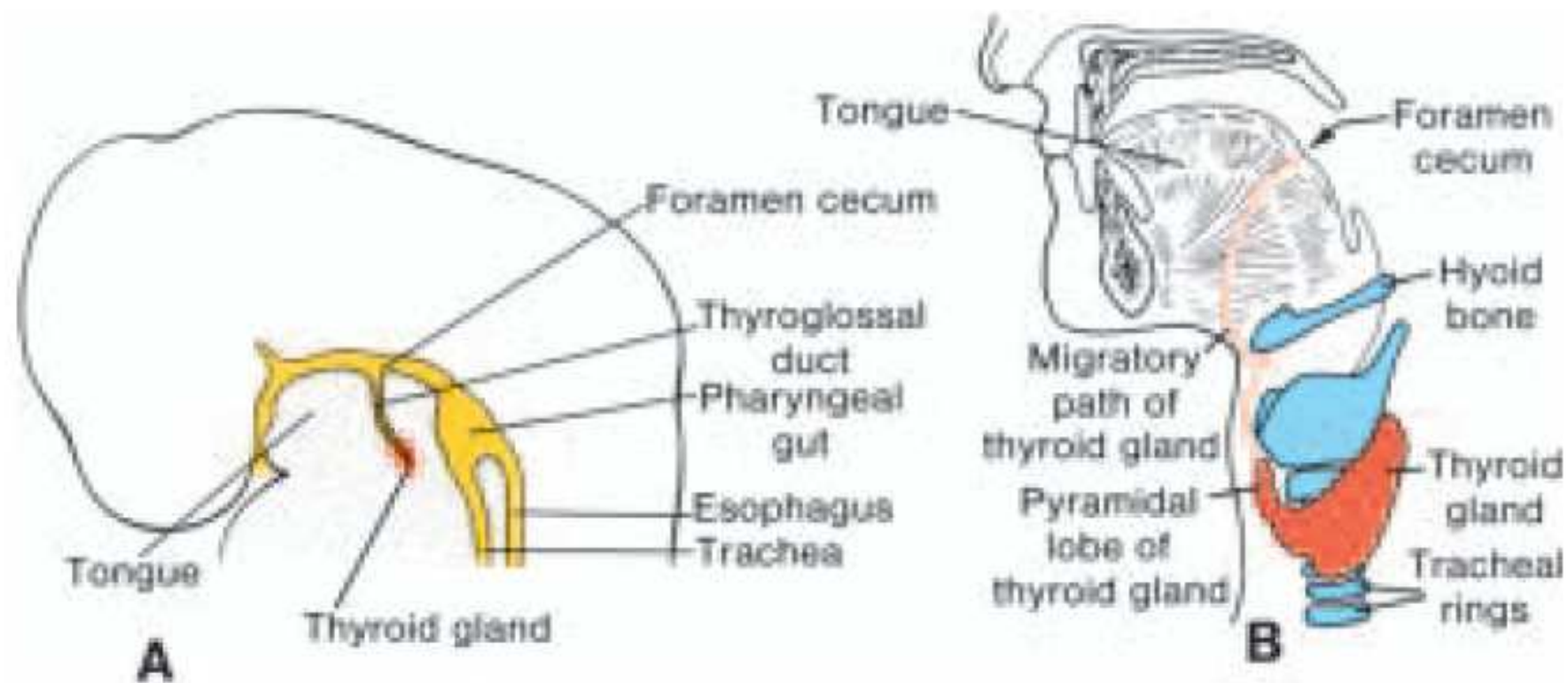
- 1- Aglossia: complete or partial absence.
- 2- Macroglossia: abnormally large tongue.
- 3- Bifid tongue: due to failure of fusion of the 2 lingual swellings.
- 4- Tongue tie: the frenulum extends to the tip preventing protrusion of tongue.

THYROID GLAND

- It appears in the 4th week as median endodermal proliferation in the floor of the pharynx between the tuberculum impar and hypobranchial eminence.
- The thickening is evaginated to form a bilobed diverticulum which descends in front of the hyoid bone and laryngeal cartilages till it reaches its final position and remains connected to the dorsum of tongue by the thyroglossal duct.
- Then, the thyroglossal duct becomes obliterated and disappears or fibrosed to form the levator glandulae thyroideae.

Congenital anomalies:

- 1- Thyroid agenesis: congenital absence leading to cretinism.

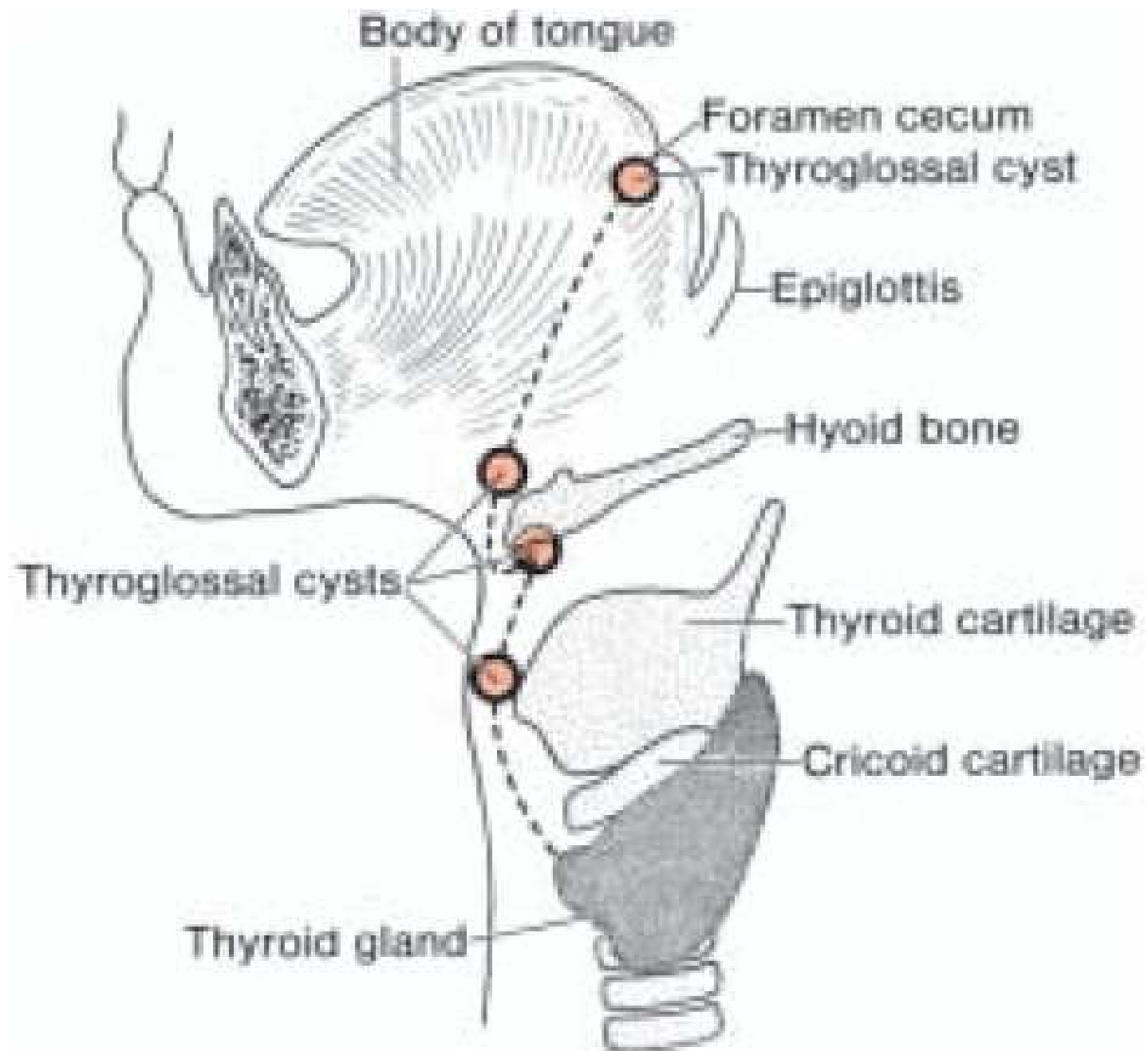


2- Lingual thyroid: the thyroid fails to descend and lies in the substance of the tongue.

3- Thyroglossal cyst: due to persistence of part of the thyroglossal duct unobliterated.

4- Retrosternal thyroid: the thyroid may descend more to reach the thorax.

5- Thyroid fistula: due to rupture of the cyst.



PITUITARY GLAND

It develops from 2 different sources:

1- Rathke's pouch: a diverticulum that grows upwards from the ectoderm of the roof of the stomodeum in front of the buccopharyngeal membrane. It forms the anterior lobe of the gland.

2- Infundibulum: a diverticulum that grows downwards from the floor of the diencephalon in the direction of Rathke's pouch to form the posterior lobe of the gland.

- The infundibulum and Rathke's pouch meet together.**
- By the end of the 3rd month, Rathke's pouch loses its connection with the stomodeum.**

